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PRODUCER GAS EQUIPMENT ON TRACTORS
IN WESTERN AUSTRALIA.

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(At present on loan from the State Department of Agriculture to the Institute of Agriculture in the University of Western Australia for agricultural economics research.)

INTRODUCTION.

When wood or charcoal is burnt in the presence of only a limited supply of air it gives rise to a mixture of gases known collectively as producer gas, suction gas, wood gas, charcoal gas, etc. This mixture of gases consists principally of carbon monoxide and hydrogen, which are inflammable, and the non-inflammable gases carbon dioxide and nitrogen. If water vapour is introduced into the generator the proportion of hydrogen in the mixture is increased.

The use of this gas mixture in internal combustion engines has been practised for many years, but has been confined chiefly to the stationary engine, where the weight and size of the necessary generator and cleaners are unimportant. Its successful utilisation as a fuel for motor-powered vehicles presents difficulties, but from time to time efforts have been made to adapt it to them.

Countries most interested, for both economic and political reasons, in the utilisation of producer gas as a source of power are those dependent on foreign supplies of oil. If producer gas could be used for motor vehicles it would be cheaper than using imported petrol and, in addition, would greatly decrease the vulnerability of the country in time of war. European governments in particular have been interested in the latter aspect of the situation and have been experimenting for years in endeavours to overcome the problems connected with the substitution of wood or charcoal gas for petrol.

The use of producer gas in agricultural tractors has also received attention in Europe and the "International Review of Agriculture" for 1927-1930 contains several references to charcoal burners and gas generating plants. In England in 1928 the "Implement and Machinery Review" made favourable comment on a Parker Bros. gas plant attached to a Fordson tractor. The design of this plant appears very similar to those which have been developed in this State.

Many of the difficulties associated with the use of gas could be surmounted in an engine specifically designed to burn this type of fuel. It is thought likely that tractor engines of this type are in existence in Russia, while the "Interna-

tional Review of Agriculture'' for April, 1938, briefly reviews some work at Stuttgart, Germany, connected with the designing of a small tractor engine to burn wood gas.

However, the problems of immediate concern are connected with the conversion of kerosene tractor engines to operate on gas.

The essential features of the majority of plants operating in Western Australia are—

- (1) a metal container of cylindrical shape containing 80-100 lbs. of charcoal;
- (2) a small water tank and drip tap; and
- (3) a series of cleaners or scrubbers in which the gas is cleaned and cooled before it enters the engine.

The gas is formed by passing air and steam through a very hot fire maintained at the bottom of the charcoal in the container.

HISTORICAL.

In Western Australia the first stimulus to the farmers' interest in producer gas as a substitute for kerosene in tractors came through the collapse of wheat prices in 1930. Every possible way of reducing costs had to be considered. In the case of the owners of kerosene tractors one of the heaviest items of expenditure in the yearly budget was fuel. Australia has only negligible oil resources and practically all supplies have to be imported. On the other hand there are large quantities of wood suitable for conversion into charcoal, particularly in Western Australia. Any method, therefore, which would enable tractor operators to substitute charcoal, often burnt from waste timber on their own farms, for costly imported fuel was worth a trial even though the working efficiency of the tractors might be reduced.

The first producer gas unit on a tractor in Western Australia was used at Xantippe about 1931. It was a plant of English manufacture but does not appear to have been particularly successful. It was seen by Mr. P. Salvaire of Manmaning who had previously operated a stationary producer gas engine at Northam. Mr. Salvaire shortly afterwards constructed and fitted producer gas plants to a Rumely tractor, a Fiat tractor and a Vulcan truck. All these machines and gas plants are still in working order though the gas equipment is not now in constant use. The plant fitted to the Rumely appears to have been the first one constructed in Western Australia.

Others followed this example and for a time there was considerable interest displayed in producer gas. Many plants were failures from the start. Others depreciated rapidly owing to faulty construction. On the other hand some farmers showed extraordinary ingenuity in building and successfully operating gas plants on their tractors for a number of years. With the recovery of wheat prices interest in gas began to wane, but some of those who reverted to kerosene fuel tractors were ready to admit that the change over to producer gas for two or three years during the worst of the depression had enabled them to stay on their farms.

Several firms and individuals were for a time interested in the manufacture and sale of gas units, but none of them was in a position to spend the necessary time and money in research and experimentation before putting their machines on the market. In consequence there were often some very dissatisfied purchasers who, after a short trial, resolved they would not again have anything to do with producer gas.

Towards the latter end of 1937 there was a revival of interest in producer gas. The possibilities of war and the curtailment of oil supplies had turned public attention to its potentialities as a substitute for petrol and kerosene. There were indications of another period of low wheat prices, which meant that farmers would

again be seeking for means whereby their cash outlay could be reduced. As a result of the practical experience gained in the past the gas plants then being marketed were decidedly in advance of those obtainable four years previously, and the advent of a new company to manufacture a plant designed as the result of some years' experimentation, gave grounds for hope that further improvements would be forthcoming.

In 1937 money for research work became available from the Commonwealth grant to Universities and an allocation was made to the Engineering School in the University of W.A. for carrying out investigations into the mechanical problems involved in the use of producer gas for tractors, etc.

In 1938 money from the same source supplemented by a grant from the Trustees of the Wheat Pool of Western Australia enabled studies in agricultural economics to be initiated in the Institute of Agriculture in the University of W.A. The first subject selected for investigation was that of tractor operations in the wheatbelt, and in order to supplement the work of the Engineering School it was decided that special attention should be given to producer gas. The first step in this connection was to obtain an accurate picture of farmers' experiences with gas. Questionnaires were therefore sent to as many people as could be located who had used gas plants on tractors. This paper is based largely on the replies received to 67 of these questionnaires supplemented by personal visits to a number of operators. It sets out the chief problems which have been encountered in the past and gives some indication of the degree to which they have been overcome.

Statistical information supplied by one of the oil companies disclosed that at the end of 1937 the 4,548 tractors in Western Australia could be classified into the following types:—

Spark tractors burning kerosene	3,924
Diesel and semi-diesel or hot bulb tractors	562
Spark tractors burning producer gas	62

Since that date the number of producer gas tractors has risen to over 200.

MAKES OF GAS PLANT.

The different makes of plant used on the 71 tractors for which information was obtained by questionnaire have been allotted distinguishing letters. The numbers of each type, together with information concerning the numbers which had been discarded prior to filling in the questionnaire, are shown in Table I.

TABLE I.

Make of Gas Plant.	Number included in Survey.		
	In Use.	Discarded.	Total.
A	...	2	2
B	3	5	8
C	19	8	27
D	1	4	5
E	27	1	28
F	...	1	1
Total	50	21	71

Types A, B and F represent makes which are not now sold. Home constructed plants have been designated type D. Types C and E are both obtainable at present

but C has been on the market for considerably longer than E and consequently is represented by a greater proportion of older plants.

At the recent Royal Agricultural Show at Claremont four types of producer gas plants were included in the trade exhibits. These were types C and E, and two makes not previously on the market.

MAKES AND H.P. OF TRACTORS.

In Table II. are given data concerning the makes and rated draw bar horse power of the tractors included in the survey. The figures in brackets indicate the number in each class which were fitted with pneumatic tyres.

TABLE II.

Make of Tractor	Rated Draw Bar Horse Power.											
	12.	15.	17.	18.	20.	22.	23.	25.	26.	27.	30.	Total.
Case	2 (2)	3	.....	27 (15)	.....	1 (1)	.....	1	1 (1)	.....	5 (4)	40 (23)
McCormick-Deering		11 (3)	.....	.....	.....	.....	.....	.....	.....	.....	.....	11 (3)
John Deere		5 (3)	.....	.....	.....	.....	.....	.....	.....	.....	.....	5 (3)
Twin City			3 (2)	.....	.....	.....	.....	.....	.....	1 (1)	.....	4 (3)
Hart Parr				2 (1)	.....	.....	.....	.....	.....	.....	.....	2 (1)
Caterpillar		2	.....	.....	.....	1	.....	.....	.....	.....	.....	3
Wallis					2 (1)	.....	.....	.....	.....	.....	.....	2 (1)
Massey-Harris								1 (1)	.....	.....	.....	1 (1)
Vickers							1	.....	.....	.....	.....	1
Ronaldson Tippet						1	.....	.....	.....	.....	.....	1
Rumeley		1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Total	2 (2)	22 (6)	3 (2)	29 (16)	2 (1)	3 (1)	1	1	2 (2)	1 (1)	5 (4)	71 (35)

Forty-nine per cent. of the tractors operated on pneumatic tyres and 4 per cent. were of the crawler type. The horse powers given are the rated figures for horse-power available at the draw bar when the tractor is working on kerosene and is not fitted with pneumatic tyres. When converted to producer gas it can be assumed that the tractors in the survey would be capable of developing, on an average, from 70%-80% of these figures. In the case of those tractors fitted with pneumatic tyres, however, the figures given would approximately represent the power available when on gas.

The widespread adoption of pneumatic tyres for farm tractors in Western Australia during the past two years, has considerably enhanced the possibilities for the successful utilisation of producer gas. Vibration on the tractor is considerably reduced—an important point when a gas plant is attached—and the extra power available at the draw bar will usually more than counterbalance any loss due to converting the tractor to gas.

AGE OF TRACTORS.

Information was obtained concerning the ages of some of the tractors when gas plants were fitted and is given in Table III.

TABLE III.

Age of Tractor when Plant Fitted (Years).												
No. of Tractors	When Purchased or less than 1 Year	2	3	4	5	6	7	8	9	10	Over 10	Total.
	13	3	1	1	6	2	5	3	3	5	2	44

From this it will be seen that there were probably instances in which gas plants were fitted on tractors which were already worn out and would perform inefficiently even on kerosene.

Of the forty-five operators who were still using gas at the time of the survey one had worked his plant for six years, five for five years, three for four years and seven for three years. Twenty-one plants had been in use for less than one season.

Twenty reports were received from tractor owners who had discontinued the use of gas. One had worked his plant for four years, three had used theirs for three years and five for two years. Seven had used them for less than a season, one man returning his to the agent after three weeks' work.

The information given in the preceding tables indicates the variety of conditions under which endeavours were made to substitute gas for kerosene, and it is hardly surprising to find that a number of those who tried it were disappointed with the results.

Of the twenty who reported they had discontinued using their gas plants, two were satisfied with them but one had given up farming and the other was away from his place most of the time and could not get a reliable man to work his plant. Reasons advanced by the others for discarding their plants were loss of power and consequent delay in getting through the work, too much time taken in looking after the plant, ignition troubles, valve trouble, rusting away of shell of plant, dirtiness of operation, excessive engine wear, difficulty in obtaining good charcoal. In view of the importance of these points they will be briefly examined in the light of the knowledge gained from numerous sources during the course of this survey. Most of them are at present being investigated in the Engineering School, which will publish reports in due course. In the meantime the following general remarks will not be out of place.

LOSS OF POWER.

Due to the difference in calorific value it is not possible to obtain as much work from a given volume of producer gas at a given temperature as from the same volume of kerosene vapour at the same temperature. However, it is possible to make certain modifications to the engine which will enable some of this loss of power to be regained.

As a result of the necessity for adequate vaporisation, the mixture of kerosene and air is drawn into the cylinder at a high temperature. As there is not the necessity for these high temperatures with gas, it can be taken into the engine at a much lower temperature than can kerosene and consequently a greater weight of gas can occupy the same cylinder space. The replacement of the kerosene manifold by a cold manifold is usual when converting to gas. This enables a small increase in power to be effected.

Kerosene tractors are usually built with a compression ratio of about 4.5:1. Increased compression will give greater power, but with kerosene there is the difficulty of pre-ignition if the compression be appreciably increased. As this difficulty does not occur with producer gas it is possible to obtain an increase in power by increasing the compression ratio, but as the tractor has to be started on petrol this cannot be done beyond a point where high grade spirit can be used without the risk of detonation. In a large number of cases the ratio adopted for gas is about 7:1.

Most of the tractors included in the survey had compressions increased to some extent, though there were exceptions. In some cases compression was increased merely by bolting plates on the top of the old pistons. However, this is not a method that can be recommended; proper high compression pistons or a high compression head should be fitted, otherwise trouble is likely to follow.

There are some makes of tractors in which it is possible to bore out the cylinders and fit oversize sleeves, thus giving an increased bore and consequent increased power. Only one or two of the tractors included in the survey were treated

in this manner, but it is understood that several of the tractors recently fitted with plants have had these alterations made, and as high compression pistons are fitted at the same time their power output should be brought back nearly in line with what it was when using kerosene.

When buying a tractor difficulties connected with possible loss of power can be avoided by obtaining one of greater rated horse power than would be necessary if it were to operate on kerosene. This entails a fairly appreciable increase in capital outlay which tends to offset the advantage of cheap fuel costs possessed by the gas driven machine.

With the use of gas and high compression ratios, best results are obtained by advancing the spark. However, the higher compressions bring increased liability to ignition trouble, a fact which was made very clear by the survey.

IGNITION.

Nearly 50 per cent. of the operators who answered the questionnaires had experienced and recognised ignition troubles of some kind. In most instances these can be attributed to the use of gas, or perhaps more properly to the engine modifications made when gas was adopted. With high compression ratios greater demands are made on the electrical system. The magneto has to be maintained in first-class order, otherwise a change to battery ignition is advisable. Many operators found it necessary to decrease the gap between the points of the spark plugs and adjust them more frequently. A cooler burning type of plug than is used with kerosene is advisable, but the most suitable types for different tractors do not yet appear to have been established.

Although troublesome, the importance of ignition breakdowns encountered when using gas should not be over-estimated. As several operators have found for themselves a change to battery ignition will usually overcome most of them; in fact, one man stated that after fitting battery ignition all his troubles with the gas plant disappeared completely. However, battery ignition adds to the capital outlay involved when converting to gas.

VALVES.

Valve trouble had been experienced to varying degrees by 50 per cent. of the operators who replied to the questionnaire. It usually took the form of tarry materials being deposited on the valve stems and preventing them from working freely in the guides. In several instances the operator had discovered for himself that the real cause of the trouble lay with incompletely burnt charcoal giving rise to volatile substances, which passed through the cleaners and deposited in the engine. By making certain that only well prepared charcoal was used a lot of this trouble was overcome. Further assistance in avoiding sticking valves has sometimes been afforded by the fitting of a drip feed to the valve stems. This enables the valve stems to be lubricated by oil or, better still, a mixture of oil and kerosene.

A few cases were investigated in which excessive deposits were being formed in the cylinders or on the valves, where the cause could not be ascribed to badly burnt charcoal and where the deposits were not of a tarry nature. The information given by those who had experienced the trouble, suggested that a mineral salt was being deposited in the engine. In only one instance was it possible to obtain a sample of these engine deposits. This was taken from a tractor which for several months had been working satisfactorily on producer gas. Charcoal was then used which had been burnt from timber obtained from a different locality to that from which previous supplies had been drawn. Trouble was shortly afterwards experienced and when the cylinder head was removed heavy deposits of a brown material were found.

Mr. R. Harvey, of the University Institute of Agriculture, kindly volunteered to analyse the deposits. The details of this analysis are given in Appendix No. 1.

The analysis suggests that among other things, salt was finding its way through to the engine, and as the only possible form in which this could carry over from the generator would be in the form of a fine dust, it appears as though the gas cleaners were not entirely efficient.

At the time when the above analysis was made, an examination was also made of a white crumbly deposit taken from the wall of the same producer gas generator immediately above the fire zone. As this was largely composed of calcium oxide it seems likely that there was an appreciable amount of combined calcium in the charcoal and in the wood from which the charcoal was prepared, and that this volatilised in the producer and in cooling was deposited in the walls. However, the information so far obtained on this point is only sufficient to suggest possibilities for further investigations.

CLEANERS.

The weakest feature of the producer gas plants fitted to the tractors investigated in this survey appears to be the cleaners for the gas.

Only 50% of the operators gave an unqualified "yes" in reply to the question "Are the cleaners satisfactory?"

There are some tractors on which the cleaners are achieving their object, but, on the other hand, it is evident that what suits one type of tractor is not necessarily suitable for another make and that the efficient working of the scrubbers is affected by such factors as speed, load, etc.

The usual procedure is to have the gas pass through two dry cleaners, where by means of a series of baffles, or by imparting revolving motion to the gas so that heavy particles are thrown to the outside, the larger particles are removed. The partially cleaned gas is then drawn through an oil cleaner with the object of ridding it of the finer dust particles.

The effectiveness of these arrangements varies considerably. In some cases appreciable amounts of the oil used in the cleaners are actually consumed in the engine, either through being sucked in in liquid form or by being vaporised and carried in with inadequately cooled gas. Both these conditions are undesirable, for if oil is being carried in in its liquid form it will carry over some of the dust and grit extracted from the gas; on the other hand if it is vaporising then the gas is entering the engine at too high a temperature.

CHARCOAL.

Good charcoal is essential for the efficient operation of a producer gas plant, but from the information collected during the survey it appears that the quality of some of the charcoal used often leaves much to be desired. Charcoal burners operate in the Darling Ranges some 30 miles east of Perth, and charcoal is obtainable from them at about £2 5s. per ton. If bought in minimum lots of 7 tons (a small truck load) freights are not excessive as will be seen from Appendix II., but if smaller quantities are purchased a much higher rate has to be paid. Despite the fact that most farmers are able to land charcoal on their farm at somewhere near £3 per ton, it was found that 75 per cent. of those included in the summary elected to burn their own requirements.

In indicating their choice of woods for preparing charcoal there was a decided preference shown for wheat belt timbers and wandoo or white gum, as against the jarrah which forms the bulk of the charcoal burnt in the hills. With most farmers who had used them, charcoal from white gum or mallee roots was preferred. These timbers appear to give a denser coal which does not burn as hot as jarrah, and which will keep alight better and give more power per unit of weight.

Trouble has also been experienced with bought jarrah charcoal on account of it containing ironstone gravel, which causes excessive clinker formation in the grate of the producer and frequent stops for cleaning out. As it is very difficult on most of the plants at present in use to remove the grate without allowing time for it to cool after the fire has gone out, this causes a serious loss of time. Careful screening of charcoal will eliminate much of the trouble of this type.

It will be seen that there is scope for a considerable amount of investigational work into the relative values of the different woods for charcoal production, and also on the effect of environment, *e.g.*, proximity to salt lakes, on the suitability of timbers for charcoal.

FUEL CONSUMPTION.

The producer gas tractor utilises charcoal and water as fuel, and, in addition, requires a small quantity of petrol for starting. Information was sought in the questionnaire concerning the quantities used when working for ten hours under full load. In the case of the 18-32 h.p. type tractors, which accounted for 56 per cent. of those covered in the survey, fourteen which were fitted with the same make of gas plant consumed on an average 246 lbs. of charcoal, 3.3 pints of petrol and 4.6 gallons of water per day.

It would be reasonable to expect that these tractors would be capable of developing on gas at least 70 per cent. of their rated kerosene horse power of 32, *i.e.*, 22.5 horse power. Tests at the Engineering School suggest it is rather unlikely that, under average conditions, it would be possible to obtain a lower charcoal consumption than 1.5 lbs. per brake horse power hour. On a basis of 1.5 lbs. per brake horse power hour, therefore, if developing 22.5 horse power, these tractors should have consumed 337 lbs. of charcoal per day. Even with the 1.25 lbs. which might be obtained under very favourable conditions the consumption would be 280 lbs.

The amount of water consumed is also too low, as a normal figure would be 0.37 lbs. per brake horse power hour giving a daily consumption of about 8 gallons per tractor.

Similar figures were calculated for all the tractors in the survey. The average rated brake horse power was 34 and the tractors on gas should, therefore, have been capable of developing 24 horse power, and for ten hours' work under full load they should have consumed some 360 lbs. of charcoal and 9 gallons of water. The actual figures, however, were 248 lbs. of charcoal 3½ pints of petrol and 5½ gallons of water.

Some of the operators who appeared to be using unduly small quantities of charcoal were asked to confirm the figures given, but as a result nothing more than minor alterations were made. There was no correlation between operators reporting unusually high loss of power as compared with kerosene and those giving low figures for charcoal consumption. It would be unwise to attach too much importance to these figures as they are possibly due to the fact that many of the tractors could not have been working at full capacity for the whole of the ten working hours. However, further information upon this rather interesting point will possibly be available when the field tests, at present being conducted by officers of the Engineering School with producer gas powered tractors, are completed.

In addition to charcoal, water and petrol, the producer gas tractor uses grease and engine oil as do kerosene tractors, and also in most cases a certain amount of crude oil or sump oil in the final gas scrubber. The oil in this gas cleaner has to be changed from time to time but, in addition, a small quantity usually disappears each day by being drawn through into the engine and burnt. Normally this should not exceed about one pint per day, but a few cases were encountered where something was at fault and the engine was drawing through and burning a considerable quantity. Needless to say a situation in which crude oil contaminated by dirt and

grit is burnt in an engine designed for kerosene is bound to lead to serious trouble. Estimates of the yearly saving effected in fuel and oil by using producer gas instead of kerosene, were asked for. These of course varied according to the acreage covered, size of tractor, hours used, etc. The answers also varied considerably and were not all on a comparable basis, but the general impression gained was that savings in fuel would amount to 70-80 per cent. of the expenditure on kerosene and that the bill for lubricating oil would be reduced by from 50-75 per cent.

REPAIRS AND DEPRECIATION ON TRACTOR.

If the repairs and depreciation on the tractor itself are increased as a result of fitting a gas generator, then some or all of the advantages gained by the use of the cheaper fuel will be lost. Operators were, therefore, asked whether in their opinion (a) depreciation had been increased or decreased and (b) whether expenditure for overhauls and repairs had been increased or decreased as a result of the conversion. The replies to these questions are summarised in Table IV. The figures in brackets refer to the 14 tractors of 32 horse power fitted with a late model gas plant.

TABLE IV.

Expenditure.	Depreciation on Tractor.	Overhauls and Repairs.
Increase	12 (1)	15 (2)
Decreased	31 (7)	14 (4)
Unaltered	14 (3)	18 (3)
Indefinite or no reply	10 (3)	20 (5)
Total	67 (14)	67 (14)

Provided that the necessary alterations to the tractor have been correctly made, that properly burnt charcoal is used, and that clean gas is supplied to the engine, costs under the headings of depreciation and overhauls and repairs for the tractor itself should be certainly not greater than with kerosene. That these conditions are not always realised in practice is obvious from the table. Excessive depreciation can be caused by unsatisfactory cleaning of the gas, while increased overhauls may be rendered necessary by the same cause or by the use of imperfectly burnt charcoal causing tarring of the valves or ignition troubles. However a number of the operators undoubtedly were obtaining good results and in reply to the question, "What stoppages or breakdowns have you had which you could attribute to the use of gas?" 21 of the 59 who replied said "none," seven of these were in the group of 14 already referred to. In a number of other cases the breakdowns were of only minor importance.

DAILY ATTENTION.

The producer gas powered tractor is at some disadvantage as compared with the kerosene tractor in respect to daily labour requirements. Each morning the residual charcoal and ash has to be taken from the generator. With the majority of plants a fairly heavy iron grate has to be removed and the clinker cleaned off it. The generator then has to be refilled with charcoal, a fire lit and the engine started and run on petrol for a short period in order to get the fire drawing well. It is usually necessary to stop and refill the generator with charcoal in the middle of the morning, at lunch time and again in the afternoon.

A certain amount of attention to the cleaners is also necessary. In order to obtain some idea of the time necessary for these operations those to whom question-

naires were sent were asked for an estimate of the extra cost involved on a basis of 1s. per hour for labour. These replies ranged from nothing to 2s. 6d. per day. Even if the latter figure be taken it does not suggest that the extra amount of daily service required is likely to be a factor limiting the use of gas plants.

GENERAL.

There are a number of other points raised by operators, some of which can be classed as minor disabilities associated with the use of producer gas.

The gas plants fitted on many of the tractors have generators the tops of which are as much as 7 ft. from the ground, and reaching up to empty a 50-60 lb. sack of charcoal into one of these when it is hot, is a job not unattended by an element of risk. Also handling charcoal is a dirtier job than handling kerosene, and a mixture of oil and charcoal dust is particularly unpleasant. Each stop for refuelling means that the fire dies down and it is not always possible to start the tractor again directly on gas.

The extra controls and the necessity of having to regulate by hand the quantity of water entering the producer, are disadvantages which make the tractor somewhat more complicated to operate than is the kerosene machine.

The plants are usually heavy, bulky and unsightly. As fitted to some tractors they obstruct the view of the driver and a few complaints were heard of faulty construction and attachment to the tractor. In one or two instances operators complained of discomfort in hot weather due to the close proximity of the gas generators.

Danger of fire when harvesting does not appear to be serious provided reasonable precautions are taken, mainly when re-fuelling.

Suggestions made by operators for improvement of gas plants included more efficient gas cleaners, use of drop grate instead of the screw on type, better cooling of the gas, check valve to prevent back pressure of engine to generator, utilisation of wood instead of charcoal, instalment of a super-charger, arrangement for grate removal without interfering with fire, an engine designed specifically for gas, lighter and more compact plant, lower initial costs (at present it costs about £85 to convert to gas) and automatic water feed.

The final point dealt with in the survey was the attitude of operators towards producer gas. Did falling prices force them to turn to a cheaper fuel, even though it might entail a serious reduction in efficiency? If so then it appeared that as soon as prices recovered there would be a tendency to revert to kerosene. Two questions were therefore, asked and those questions, together with an analysis of the replies, are set out in Table V.

TABLE V.

	Would you use Gas with Wheat at—	
	2/- per Bushel ?	5/- per Bushel ?
Yes	51	39
No	7	20
Qualified replies	5	4
No replies	4	4
Total	67	67

The replies suggest that 57 per cent. of those who replied to the questionnaire were satisfied that the reduction in costs secured by converting to producer gas was

not accompanied by corresponding reduction in efficiency. Two stated that gas would be used in preference to kerosene but that crude oil would be preferred to either. This is an important point but until some definite cost figures have been collected in connection with tractor surveys, at present in progress, comment will be withheld.

SUMMARY AND CONCLUSION.

An attempt has been made to review the present position of producer gas as a source of power for farm tractors in Western Australia. The information was obtained from 67 replies to a detailed questionnaire sent to operators, and from personal visits and interviews by the writer.

This report is supplementary to investigations at present in progress at the Engineering School into the mechanical problems associated with producer gas and at the Institute of Agriculture into the costs of operating tractors under wheatbelt conditions.

Interest in producer gas as a tractor fuel was aroused in Western Australia as a result of depressed wheat prices after 1930. Numerous attempts were made to design and construct plants but the majority were not successful.

By December, 1937, the number of plants in operation declined to about 62. Owing largely to the appearance of another make on the market the number has now increased to over 200 or about 5 per cent. of the tractors in the State.

As applied to the ordinary kerosene tractor engine producer gas has entailed an increased capital expenditure, some reduction in power and consequently in the time taken to perform a given amount of work, a decrease in reliability and certainty of operation, more intelligence and knowledge required for successful operation, in some cases a decrease and in others an increase in costs of depreciation and repairs and renewals to the tractor itself and some increase in the daily service work necessary. On the other hand it has affected considerable savings in fuel and oil costs.

The extent to which the disabilities offset the advantages have varied greatly from farm to farm and will continue to do so. Technical improvements have been and will continue to be made that reduce the degree of some of the disabilities mentioned above, but there are some that can never be completely overcome. The decision as to whether the advantages of gas outweigh the disadvantages attached to its use will be determined by the type of tractor and the purposes for which it is used, the way in which it is used and the type of man who will operate it.

There is at present ample scope for continued research into the mechanical problems connected with the use of gas particularly as interest will be heightened in it by the prospective low prices for wheat.

Instances were encountered where operators would have benefited by improved service by the sellers of plants, though whether this would have been economically possible for the sellers is another matter.

It also appeared that the establishment of a school of instruction, where operators could learn the correct method of handling their plants and how to detect and remedy faults in their early stages, would be of value in extending the popularity of gas producer attachments.

At present it is mainly a case of learning by experience, and the success or otherwise of the gas-driven tractor is dependent on the skill, intelligence and adaptability of the operator to a greater extent than it is with a kerosene tractor.

In conclusion the opportunity is taken of thanking the many people who have assisted by contributing information for this survey. The writer is particularly indebted to Associate-Professor Bowden, who is directing the research work connected with producer gas in the Engineering School of the University of Western Australia, without whose help and advice a considerable portion of this paper could not have been written.

APPENDIX I.

Analysis of Substances taken from Producer Gas Generator and Cylinders of Tractor.

Analysed by R. J. Harvey,

Institute of Agriculture, University of Western Australia, July, 1938.

Producer Deposit—

White Powder.						%
Loss of ignition (includes CO ₃)	...	...	...	...	...	5.1
CaO	...	...	...	...	...	84.5
MgO	...	...	...	...	...	10.1
Insolubles	...	...	trace	} Not estimated	...	0.3
Cl	...	...	"			
PO ₄	...	...	"			
Fe ₂ O ₃ , Al ₂ O ₃	...	...	"			
						100.0

The deposit thus consists almost wholly of calcium and magnesium oxides which have probably become carbonated to some extent after sampling.

Cylinder Deposit—

Brownish-black Scales.										%
Loss of ignition	...	...	...	...	...	...	...	...	37.6	
Fe ₂ O ₃	...	...	...	...	...	...	...	...	14.7	
Ca	...	...	...	...	...	...	...	...	5.3	
Mg	...	...	...	...	...	...	...	...	2.6	
SO ₄	...	...	...	...	...	...	...	...	10.9	
Cl	...	...	...	...	...	...	...	...	14.1	
Na	...	...	...	...	...	...	...	...	12.9	
Insolubles	...	...	trace	} Not estimated	...	...	...	...	1.9	
PO ₄	...	...	"							
Zn	...	...	"							
										100.0

APPENDIX II.

Western Australian Government Railway's Milage Rates for Goods per Ton.

(Rates for manure and firewood are inserted for comparison.)

SPECIAL CLASSES.

Miles.	Manure.	Firewood.	Miscellaneous Class.	A Class.	C Class.
	per ton.	per ton.	per ton.	per ton.	per ton.
	s. d.	s. d.	s. d.	s. d.	s. d.
1 to 10	2 6	2 7	2 6	7 6	9 4
30	2 11	4 2	5 0	10 10	16 9
50	3 3	6 2	7 0	13 8	21 9
70	3 6	7 0	8 8	16 0	25 8
90	3 11	7 10	9 9	18 0	29 9
110	4 4	8 8	10 11	20 0	33 7
130	4 9	9 6	12 1	22 1	37 5
150	5 2	10 4	13 3	24 1	40 11
170	5 7	11 2	14 5	26 1	44 9
190	6 0	12 0	15 7	28 1	48 7
210	6 5	12 10	16 8	30 0	52 1
230	6 10	13 8	17 8	31 9	55 3
250	7 3	14 6	18 8	33 4	58 3
270	7 8	15 4	19 8	35 2	61 5
290	8 1	16 2	20 8	36 11	64 7
300	8 3	16 7	21 2	37 8	66 1

Charcoal in bags in less than two ton lots is charged at the Class C rates, over two tons it comes in Class A and if loaded in wagons to their full carrying capacity it comes into the much lower miscellaneous class. It is obvious, therefore, that if charcoal has to be trucked for any distance a big saving can be made by buying truck loads instead of small quantities.

THE CONTROL OF BOVINE MASTITIS.

A General Discussion of the Problem, together with Results Obtained in Local Conditions.

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Definition of the term "Mastitis."

The term "Mastitis" signifies an inflammation of the mammary gland or udder. In the mildest cases it is shown only by an increased leucocyte content of the milk. If not due to a mechanical injury, some micro-organisms also should be present in the udder. In severe cases the affected quarter or quarters may be swollen and inflamed. In case of long standing, invasion of the udder tissues generally takes place, and hardened masses of fibrosed tissue may be detected by clinical examination.

Obviously, from the definition of the term mastitis, apart from cases caused by mechanical injury of the udder, mastitis may be caused by any organism capable of invading the udder and attacking the delicate internal tissues. Actually mastitis cases are known to be caused by streptococci, staphylococci, organisms of the bacterium coli group, brucella abortus and mycobacterium tuberculosis.

The mastitis cases of greatest importance from an economic standpoint are those which are caused by invasion of the udder by the organism, "Streptococcus agalactiae" (syn. "Str. mastitidis"), for such cases apparently never recover completely, even though periods of apparent normality are experienced; and, as the disease is infectious, the affected animals are a menace to the clean members of the herd. The majority of mastitis cases are of this type.

Constitutional Symptoms of Mastitis.

In cases of acute mastitis the constitutional symptoms appear suddenly. Often a shivering fit is the first symptom noticed by the owner. The animal is restless, pulse frequent and the temperature if recorded at this stage is high, often up to 108 deg. F. Appetite and rumination are temporarily suspended. The cause of the trouble may not be suspected until the udder is examined and the inflammatory changes and secretory derangement are then detected in the organ.

The Detection of Mastitis.

(1) Clinical Tests.

The clinical cases are those which are most readily detected. In bad cases the affected quarters are swollen, inflamed and painful. The milk from such quarters may be thick and ropy. Sometimes it may show little or no resemblance to milk, being a thick, semi-gelatinous secretion of a yellowish or brownish colour. At times the secretion is a thin, somewhat clear, brownish fluid. In the cases where the acute or inflammatory stage has passed the secretion may again appear nearly normal, but it often contains white or cream coloured "clots" of varying size. The clots may be sufficiently large to be readily recognised, or may be so small as to be difficult to see; such small "clots" are more readily seen by collecting some of the milk on a glass plate, allowing most of it to drain off and then examining the plate in a good light.

In old chronic cases fibrosed areas may generally be detected by palpation of the udder after it has been thoroughly stripped.

(2) Colour Tests.

The colour test method for the detection of mastitis has been shown to be far too unsatisfactory in the results it gives to have any real practical value. This test method has been discussed previously in this Journal. (Jr. Dept. Agric. W.A., XV. (Second series), 3, 281).

(3) The Catalase Test.

Catalase is an enzyme which is contained in the leucocytes. Thus, an estimation of the catalase content of the udder secretion is an indirect estimation of the leucocyte count and, insofar as one considers that leucocytosis is synonymous with mastitis, this test should be an accurate test for mastitis.

To test for catalase use is generally made of its property of decomposing hydrogen peroxide with consequent liberation of oxygen.

The most simple method of conducting the test is that described by Orla-Jensen (Dairy Bacteriology). A graduated tube of 20 ml. capacity is fitted with a rubber stopper and S-shaped pieces of glass tube. 15 mls. of milk are introduced into the tube and sufficient hydrogen peroxide (1-3 per cent.) is added to fill it. The stopper with its tube is replaced and the apparatus inverted. The number of mls. of oxygen evolved in six hours at room temperature is taken as the catalase number.

A variation of the test to give a colour indication has also been proposed (Vet. Med. 32, 29-31, 1937). The variation in colour obtained when P-phenylenediamine hydrochloride is added to the mixture of milk and hydrogen peroxide is noted. Normal milks produce a blue colour, mastitis milks no colour.

The data presented in the literature shows no close correlation between leucocyte counts and catalase numbers. However, such cannot be expected, as a smear of milk, by chance containing a spot of pus, will show a very large cell count relative to a smear containing no spots of pus prepared from the sample. The obtaining of an average cell count in such cases is almost impossible. Further, the agglomeration of the leucocytes into masses in the pus accentuates the difficulty, and a variable percentage of the total cells will be cells other than leucocytes, such as epithelioid cells.

The data, however, does show a general tendency for high cell counts to run parallel with high catalase numbers. It also indicates that a cell count greater than 100,000 per ml. or a catalase test greater than 2.5 mls. of oxygen (obtained according to the above technique) is a good indication of udder infection. The tendency is to accept these limiting values for the cell count and catalase numbers as indicators of udder infection.

It should be noted that, as the catalase test is obtained with a sample of milk relatively large to the quantity used for the direct microscopic examination test, it should give a more average indication of the degree of abnormality of the milk.

The catalase test has not been utilised in the local investigation for the reason that, although it is apparently a good method for detecting milk samples which have a high leucocyte content, i.e., milk samples drawn from mastitis quarters, it gives no indication of the type of infection which is present.

Other chemical tests have been proposed for the purpose of detecting mastitis infections (e.g. the chlorine concentration of the milk), but these tests appear to have a less fundamental basis than the catalase test and to give less accurate results.

(4) The Microscopic Examination of the Milk.

The method used by the writers for the microscopic examination of the milk has been previously described (Jr. Dept. Agric. W.A., XV., second series, 3, 281), but for the purpose of keeping this paper complete in itself, the description of the method will be included.

The mastitis cases which the bacteriologist generally wishes to detect are those caused by streptococci. The number of organisms in the milk from such mastitis quarters is very variable; in acute cases the number may be many millions per ml. but in chronic cases there may be so few as to be easily missed upon microscopic examination. To be more sure of detecting the streptococci it is preferable to give the milk samples a preliminary incubation at 37° C.

The following method of making the test has been followed by the writer with excellent results (Jr. Dept. Agric. W.A., XV., second series, 3, 281):—

"The selective bactericidal properties of certain dye-stuffs is well known, e.g. gentian violet at a concentration of 1 : 100,000 inhibits the growth of most Gram-positive organisms but allows the growth of most Gram-negative species. The use of brilliant green at a concentration of 1 : 50,000 to obtain a selective growth of the streptococci causing contagious streptococcal mastitis was suggested by Bryan and Huber (Bull. Inst. Past. Rev. et Anal. XXXIII., p. 1112), and is used in this laboratory.

Sterile bottles, with a mark to show the level reached by approximately 50 mls. of liquid, are used as sample bottles. Five mls. of an "aged" solution of brilliant green is added to each bottle, the addition being carefully made to maintain sterility. The "aged" solution of brilliant green is prepared from Grubler's dye and sterilised distilled water prepared in a still fitted with a block-tin condenser. The concentration of dye in the solution is 1 : 5,000. The solution is kept for at least two weeks before use.

Before collecting the milk samples three or four streams of milk are discarded. The bottle is then filled to the 50 ml. mark. Separate samples from each quarter are taken and all precautions to avoid the entrance of extraneous organisms are observed.

The samples are incubated overnight in the 37° C. incubator. The time of incubation is about 18-20 hours.

Smears are then prepared for microscopic examination according to the method used for the "direct count," as described in Journal Dept. Agric. W.A., XIV., March, 1937, pp. 65-73, Leaflet 504.

Samples showing the presence of leucocytes and long chain streptococci are classed as "mastitis positive." Samples showing leucocytes in excess of 100,000 per ml., but no streptococci, are classed as "mastitis doubtful." Samples showing no streptococci and having a leucocyte count of less than 100,000 per ml., are classed as "clean."

The significance of this classification will be discussed directly, together with a discussion of its importance in the control scheme.

The Treatment of Mastitis.

Many claims have been made for various treatments for the cure of mastitis. Treatments advocated include fomentation and massage, etc., irrigation of the udder with antiseptic solutions, and the use of vaccines, etc.

As regards the fomentation and massage treatment, it may be said that its only value lies in relieving the suffering of animals during the acute stage of the disease and possibly hastening the cure of animals affected with a very mild form of mastitis, other than streptococcal.

For the second method of treatment two antiseptics in particular have been advocated. These are known as "Entozon" and "Aeriflavine." "Aeriflavine," which is well known as an antiseptic in medical practice, would appear to have great possibilities because its germicidal activity, contrary to the usual finding with antiseptics, is enhanced in the presence of serum.

The following figures show the concentration of "Acriflavine" necessary to inhibit the growth of *Staph. aureus* and *B. coli*. (Extra Pharmacopoeia XX., Vol. II., 1935, p. 648).

Organism.	Concentration in 0.7 % Peptone Water.	Concentration in Serum.
<i>Staph. aureus</i>	1 : 2 x10 ⁴	1 : 2x10 ⁵
<i>B. coli</i>	1 : 1300	1 : 10 ⁵

Encouraging results have been reported with these substances, particularly "Acriflavine," in England. (Vet. Record 50, No. 23, June, 1938, p. 663.) On the other hand experiments carried out locally by the writers have so far given disappointing results.

Many experiments have been conducted with vaccines. As a result of a general survey of the literature prior to their work, coupled with their own findings, Plastridge et alia concluded that such treatments were unsatisfactory (Agric. Expt. Stn. Storrs Conn. Bull. 197 (1934)). The following quotation is taken from the summary in that bulletin:—

"In general, the results obtained with bacterins, show that (1) periodic injections of autogenous herd bacterins fail to bring about complete recovery of affected animals; (2) they reduce but slightly the rate of spread of infectious mastitis; and (3) they apparently aid somewhat in retarding the occurrence of milk abnormal in appearance by animals recently affected with the disease.

Evidence of recovery was no greater in treated than in untreated animals and was limited almost entirely to those affected with staphylococcal mastitis or mastitis due to infection with group B streptococci. Instances of recovery in animals affected with mastitis due to group A streptococci (which appears to be the principal cause of mastitis in Connecticut herds) were rare."

The Control of Mastitis.

It has frequently been shown that troubles caused by bacteria are largely avoided by paying close attention to certain fundamental principles. Whether the trouble is an animal disease, such as mastitis, or the decomposition of a foodstuff, such as the souring of milk, or any other trouble of bacterial origin, the same fundamental principles apply. The measures taken regularly to prevent the spread of infectious diseases, such as, for example, "diphtheria," are based upon these principles. The principles may be enunciated as follows:—

- I. The foci of infection must be isolated or preferably eliminated.
- II. The causes of the transference of the bacteria must be removed.
- III. Conditions unfavourable for the growth of the organisms should be induced in the animal or foodstuff it is desired to protect.

The manner in which the principles are carried out may readily be followed in the example above mentioned, *i.e.* diphtheria. To comply with the first condition all persons found to be infected are quarantined. To avoid the transfer of the bacteria and thus avoid spread of the disease, all persons who have made contact with cases of the disease are also isolated until proved free of infection. To comply with the third condition, people in a locality infected with diphtheria are advised to have themselves inoculated and so immunised against the disease.

Encouraging results obtained by the application of so-called "sanitary control measures" have been reported in the literature dealing with mastitis. The following abstract is an example taken from the summary in Bull. 197 of the Agric. Expt. Stn. Storrs, Connecticut (1934).

"Bacterin was used in Herd F. for two years and then discontinued. Segregation and disposal of affected animals and sanitary control measures were then practised. The incidence of mastitis during the first and second year was 33.3%

and 29.4% respectively. During the third year it dropped to 16.6% and 3.8% at the beginning of the fourth year."

An experimental control scheme based upon the above-mentioned principles was commenced in one of the local herds early in 1937, and the results obtained will now be discussed.

The Initial Condition of the Herd.

The history of mastitis in this herd dates back for at least 10 years, and, when the farm was first visited by the writers early in 1937, apart from the infected animals found in the milking herd, a number of the worst cases were noted as being isolated in one of the farm paddocks.

When first tested 37 cows were present in the milking herd. Fourteen of these animals were found to be definitely affected with streptococcal mastitis, by the microscopic test method as described above, whilst six gave milk (from one or more quarters) which had a high cell count, but in which no streptococci could be detected. They were classed in the "mastitis doubtful" group. (It should be noted, of course, that the term "mastitis doubtful" means doubtful as regards streptococcal mastitis, but this will be discussed more fully directly.)

The six cows which gave the high cell count milk were apparently all intermittent shedders of streptococci; or, the streptococci in the milk were so few that none were contained in the samples, for each of the six cows were found to be infected with streptococcal mastitis in later tests. It is interesting to note that four of these animals had clinical indications of mastitis and/or a history of udder disturbances. Also, among the animals which gave no indications whatsoever of udder infection by the microscopic test method, were three with clinical indications of mastitis and/or a history of mastitis. These three animals also gave definite indications of streptococcal mastitis by the microscopic test method when later tests were carried out.

The latter findings indicate a very important point, which is, that animals showing tissue changes of the udder upon clinical examination together with animals having a history of mastitis should be segregated from the definitely healthy animals even though no indications of infection are obtained by the microscopic test method. It would appear that the streptococci may be very firmly isolated in fibrosed areas and thus not necessarily found in the bulk of the milk from the quarter.

At the time when the first test was carried out a number of animals were not in milk and these must next be considered. Excluding heifers introduced into the milking herd for the first time after the control scheme had been started, there were six such animals. Four of them were found to be definitely affected with streptococcal mastitis when first tested. The other two animals showed no evidence of mastitis and have remained clean.

Summarising these results, it will be seen that in the milking herd comprised originally of 43 animals there were 27 animals which were affected with streptococcal mastitis, *i.e.*, the incidence of infection was 62.8 per cent.

There were no animals more than four years of age which had not become infected, *i.e.*, no animal had reached the third lactation period free from infection. Further, among the infected animals which were noted up to the time when control measures were first instituted, there were nine infected animals on their first lactation period.

Control Measures Discussed.

It should be obvious that, if either of the first two principles above-mentioned could be perfectly applied, or, in connection with the third principle, an immunity

could be established in the clean members of the herd, the spread of streptococic mastitis would be stopped. However, none of these desirable conditions can be perfectly attained, and it is thus necessary to apply all three as rigidly as possible.

First Step in Control: The Removal of the Foci of Infection.

Many difficulties arise when an attempt is made to eliminate all animals affected with mastitis. The initial difficulty is that of actually detecting the disease in all animals affected. Some indication of this problem has already been given. Infected animals are of several types.

(1) Those animals which produce milk which, examined by the microscopic method as detailed above, is found to contain an abnormal number of leucocytes together with typical long-chain streptococci. The detection of these animals offers little or no difficulty.

(2) Other animals are found whose milk shows no sign of abnormality, but which have tissue changes in the udder detectable by an experienced veterinary surgeon. Those cases noted by the writers in this group eventually gave a positive microscopic test and it is considered that probably all such animals should be classed as affected. As previously mentioned, the streptococci appear to be very firmly held in the fibrosed areas and it may be some time before they are detected in the milk samples.

(3) A third type includes those animals which give milk having a high leucocyte content, but in which no streptococci can be detected. These animals form the worst cases to deal with for an extended series of tests becomes necessary. In the herd under survey only one such animal having no detectable tissue changes and no history of mastitis, was noted. This animal secreted milk in which streptococci were observed when a second test was taken, three months after the first test. This animal was probably one of the so-called "intermittent shedders of streptococci" mentioned in the literature. Probably the explanation is that the number of organisms present in the udder is so small that none happen to be present in the sample which is collected.

However, it is not possible to class all animals which secrete milk having a high leucocyte content as positive streptococic mastitis cases. The writers believe that, insofar as mastitis is merely an inflammation of the mammary gland or udder, a leucocytosis of the milk is just as accurate an indication of inflammation of the udder as a leucocytosis of any other portion of the body is an indication of inflammation of that portion, and any animal secreting milk with a high leucocyte content should be classed as affected with mastitis. But, as previously stated, inflammation may be caused by many organisms other than streptococci. It is not proposed to spend much time and space reviewing the large amount of literature on this subject. The following histories of two animals are sufficient, it is thought, to illustrate this opinion.

Cow No. 1—AGE 2 YEARS.

Date Tested :	6-4-37	14-7-37	13-10-37	3-11-37
Findings	...	...	R.B.	...
Date Tested :	9-3-38	25-4-38	27-6-38	16-8-38
Findings	...	..	R.B. ; L.B.	...

COW NO. 2—AGE 3 YEARS.

Date Tested :	6-4-37	3-11-37	29-11-37	17-1-38
Findings	R.F. ; R.B. ; L.B.	R.F. ; R.B. ; L.F. ; L.B.	...	...

Date Tested	9-3-38	25-4-38	27-6-38	16-8-38
Findings	R.B.	R.B.	...	...

In the above tables are indicated the quarters of the animals which secreted milk with a high cell count on the test days indicated.

It would seem that the leucocytosis is caused by some very mild infection which the animals are able to overcome by their normal defensive methods.

An interesting observation was made in this connection. Approximately six months after the commencement of the control scheme a severe outbreak of vaccinia (cowpox) occurred in the herd, practically all the animals being affected. Shortly after the outbreak the milk samples were tested and all showed a very high cell count. The cells appeared to be mainly degenerate polymorphonuclear leucocytes. The cells gradually decreased in numbers during the following few weeks and it would seem that the high cell count of the milk samples and the incidence of vaccinia should be correlated.

Considering next the disposal of animals which have been diagnosed as affected with the disease, one is liable to encounter further difficulties. In the first place, the incidence of mastitis in a herd is generally very high. (In the particular case under discussion it was found to be 62.8 per cent.). Thus the elimination of all the affected animals would reduce the size of the herds in many cases to a small proportion of the original size. For several reasons it will generally be impossible to replace the affected animals immediately. Firstly, the actual cost of replacement must be considered; secondly, the loss of high class breeding animals must be taken into account; and thirdly, the difficulty of obtaining disease-free animals for replacement purposes.

Taking everything into consideration, it would appear that the most sound procedure to adopt is to rigidly isolate the affected animals of the herd. Such animals are then available for breeding purposes, a particularly important point where highly bred pure blood stock has to be considered. The disease is not transmissible to calves during the early months of their lives and the isolated animals may be allowed to rear their own progeny. However, as soon as sufficient disease-free stock is available to meet the minimum requirements of a farm the affected animals should be disposed of to reduce the risk of infecting the new herd.

Second Step in Control: The removal of Causes of Transference of the Organism.

The measures to be taken in connection with the second principal above mentioned must next be considered. It is generally considered that the main agents causing the spread of mastitis are the hands of the milker, or, where machine milking is employed, the teat cups of the machine. The preventive measure to be instituted is obvious, i.e., the careful sterilisation of the milker's hands or teat cups of the machine, as the case may be, between the milking of the animals. When

hand milking is employed, the hands of the milker may be washed in a suitable disinfectant. However, when machine milking is employed the sterilisation of the teat cups is not so simply achieved. Probably the best treatment would be to immerse the milking claws in a copper of boiling water for several minutes between the milking of each animal. It has been argued with the writers that such a procedure results in losing the main advantage of machine milking, but one can hardly expect to control the mastitis in a herd without taking some trouble over the necessary control measures.

The milking of the animals in succession according to the chance of their being free from infection, is one of the most important steps in a control programme in that it reduces the chance of spreading infection. Generally, the same milkers will be required to attend all the animals. When this is the case the milking order should be—

(1) Group I. animals, i.e., animals definitely free from infection at the last examination.

(2) Group II. animals, i.e., animals with a possible streptococcal infection and definitely some type of udder disturbance—those animals classed as “doubtful” according to the previously mentioned method of classification.

(3) Group III. animals, i.e., animals definitely affected with streptococcal mastitis which have been retained for breeding purposes.

A second obvious agent for the spread of the disease is, of course, the washing equipment used for cleaning the udders prior to milking. The wash water should contain some proved antiseptic at a suitable concentration, and care should be taken to ensure that the concentration of the disinfectant is maintained. Solutions of such materials as the chlorine disinfectants, e.g., calcium hypochlorite, i.e., bleaching powder, being strong oxidising agents, rapidly deteriorate in strength due to the organic matter introduced into them during the washing process, and, therefore, require to be frequently renewed.

Flies have not been proved to be carriers of infection, but obviously the possibility that they are carriers exists. To avoid the attraction of these insects to the udders, the udders should be washed in antiseptic solution after the completion of the milking process to remove all traces of adhering milk.

When calves are allowed to mix with a number of animals, they also may cause spread of the disease by indiscriminate sucking, and, therefore, steps should be taken to ensure that calves cannot mix with clean animals and affected animals; in fact, it is best that no calves be allowed to suckle from the clean animals.

Third Step in Control: The Building-up of Resistance in the Animals.

As previously mentioned, prophylactic treatment has not been successful in the control of mastitis. (Agric. Expt. Stn. Storrs Conn., Bull. 197, (1934)). The following quotation is taken from the summary in the Storrs Stn. Bull. 197:—

“In the College Herd, Herd C, the average incidence of mastitis for a four year period was 40.5 per cent. in the treated group and 51.2 per cent in the untreated group.

In Herd B, the incidence of mastitis in the bacterin treated group, was 50 per cent. during the first year and 40.9 per cent. during the second year. The control group showed an incidence of 40 per cent. during the first year and 39.1 per cent. during the second year.”

Insofar as the maintenance of the herd in good condition mitigates against attack by any disease, this fact should be given attention. The writers' observations lead them to believe that exposure of the animals to cold, wet conditions increases the incidence of mastitis amongst the animals.

Hereditary Resistance.

Occasionally a few cows are found whose resistance to streptococcic mastitis apparently greatly exceeds the resistance of most members of the herd. Thus, one may find occasional animals of about twelve years of age perfectly free from any evidence of infection, notwithstanding the fact that they have passed the whole of their existence in a large herd where the incidence of mastitis is between 60 per cent. and 70 per cent. Some workers claim that strains of animals are to be found showing this characteristic.

The reason for this supposed resistance of certain animals is unknown. It should not be forgotten that, even regarded on a probability basis, a few animals would be expected to remain free from infection during the whole of their lives. If, however, freedom from infection of a strain of animals is proved, hereditary resistance must be accepted as an actual fact. The evidence to date points in this direction.

Either or both of two possibilities may explain an hereditary resistance. The first possibility is a serological reaction: the second, an anatomical structure of the teat itself. Little or no work has been published in connection with the first possibility, but an important paper on the anatomy of the teat of the cow has been published by Johnson (Jr. Path. and Ther. 51 (1938), p. 69). Apart from variations in the size and shape of the duct itself, this worker has noted the presence of variable numbers of small pouches and folds in the delicate epithelial lining of the sinus itself. By means of experiments carried out with carbon particles and water, it was shown that the pouches could act as lodging places for small particles, and also that small particles could be dislodged from the pouches and forced back from the sinus into the upper areas of the udder by certain manipulations of the teat.

The Experimental Procedure.

In the experiment conducted locally samples were collected from each of the animals in the milking herd. Three or four jets of milk from each teat were discarded and then separate samples collected from each. From the results of the examination of the incubated samples, the herd was then classified as described above. Note: Hand milking was employed at the farm. The following recommendations were made:—

(1) Prior to milking, the udder of each animal was to be well washed in an antiseptic solution after the milker had thoroughly washed his hands in the same solution. In order that the wash cloths should be well disinfected between each animal, the animals were to be washed one at a time, each immediately prior to milking, and the cloths then left in the antiseptic solution until required for the next animal. These measures were to be instituted at the first milking after the test samples were collected, notwithstanding that the results of the tests would probably not be available until after several milkings had been performed.

(2) The animals were to be milked in the order Group I, followed by Group II, with Group III last, as soon as the classification of the herd was available. The animals of Groups I. and II. were to be allowed in the milking shed together but those of Group III. were to be brought in separately.

(3) After milking the animals were to have their udders re-washed with the antiseptic solution.

(4) After milking, the floor of the shed was to be sluiced down with strong disinfectant solution.

(5) Those animals definitely affected were to be kept segregated from the healthy animals in separate paddocks.

It was proposed to re-examine the animals at intervals of approximately three months and reclassify them according to the new test results obtained. Actually the first three routine tests were separated by approximately this period of time, but subsequent tests were made after the lapse of a shorter period, generally about six weeks. Further, special tests were frequently made of the Group II. animals during the first twelve months of the experiment.

Experimental Results.

During the first nine months following the date of the first classification of the animals, five fresh cases of mastitis occurred among the animals of Group I., i.e., the group containing the definitely clean animals. These five new cases when initially tested showed no clinical signs of any infection, secreted milk free from streptococci and with very low cell count, and had no history of mastitis.

At first it was thought that the control measures were ineffective, but certain information indicated that the control measures advocated had not been adopted and later, definite evidence of this fact was found. e.g.—It was discovered that the milking order recommended had not even been followed.

It was explained to the farm manager that the work would have to be discontinued unless a guarantee could be given that the procedure recommended would be adhered to rigorously, and during the next nine months conditions improved. The animals, so far as is known, were milked in the order specified. The use of disinfectant solutions as recommended was followed, although at times it was noted that the strength of the disinfectant was below requirements. The disease-infected animals were not isolated in fields away from the clean animals, the manager maintaining that with the facilities at his disposal this was not possible.

Even with the poor control measures described, however, the number of fresh cases which developed was only one, which compared with the five which developed during the previous nine months, was a marked improvement.

During the period whilst the control scheme has been in operation, heifers have been added to the herd, bred from both infected and clean animals, bringing the number of animals in the disease-free herd at the end of the second nine months up to 26. Had the programme advocated been carefully followed, it is probable that the six animals which became infected would have remained free from the disease. This would have brought the total number of clean animals to 32. The period reviewed ended just prior to the fresh milking season on the farm and the number of fresh heifers expected for the new season being 12, it will be seen that in two years the herd should have been built up to include 44 animals compared with the initial total number of 43 in the milking shed.

Control Scheme Suggested for General Use.

Every thoughtful dairy-cattle owner wishes to reduce to a minimum the risk of his clean cattle becoming infected. It is suggested that the following control scheme, involving little expenditure and loss of time, should be of assistance to him in that direction.

(1) The animals should be divided into two groups as follows:—

(a) Animals which have never shown any abnormal condition of the udder such as heat, swelling or tenderness, whose udders show no signs of lumps or hardened tissue when carefully examined after stripping, and whose udders have no "light" quarters. Additionally, the milk from the animals must never have shown any abnormality such as "clots," thickness, wateriness or discoloration.

(b) All other animals than those contained in group (a).

(2) The animals in each group starting with those in group (a) are milked according to their age, commencing with the youngest, for the chance of an animal being infected increases with its age.

(3) As new stock comes into production it is added at the beginning of the milking chain, and as fresh animals obtained by breeding can be added to the herd to maintain the minimum output required, others are eliminated from group (b), disposing of the worst cases first. No animals other than heifers, should be bought and added to the herd unless they have been first properly tested and kept isolated from the time of taking the milk samples for test until the results are available.

(4) The hands of the milker, the wash water and cloths, etc., must be treated with antiseptic as described above.

(5) Any animal in group (a) showing abnormality of the milk or the udder after the commencement of the control scheme should be relegated immediately to group (b).

Summary and Conclusions.

For the detection of mastitis, milk examinations in themselves are inadequate. Clinical examinations must be conducted as well as the microscopical examination of the milk samples.

A leucocytosis of the milk, i.e., cell count in excess of 100,000 per ml., is indicative of mastitis, in general, but not of streptococic mastitis specifically. Results obtained indicate that vaccinia (cowpox) is one of the causes of a temporary leucocytosis of the milk. In the cases noted the cells were mainly degenerate polymorphonuclear leucocytes.

A control scheme, based upon the first principles for the prevention of disease, gives relatively good control of the incidence of mastitis.

“THE JOURNAL OF AGRICULTURE”

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THE BRACKEN FERN AND ITS ERADICATION.

M. CULLITY,

Senior Agricultural Adviser.

Bracken fern is widely distributed over the earth and is probably one of the oldest of plants, dating from cretaceous times. During the long period of its existence it has proved resistant to fungoid and insect attack. Actually in surviving the varying conditions of the changing times, it has proved its adaptability and extreme resistance to haphazard methods of control.

It is a common pest in the south-western portion of this State and throughout many other parts of Australia. In fact it is so common that it is accepted as a permanent resident and frequently no effort is made to control it. It covers hundreds of acres of once cleared land which otherwise could carry useful pastures.

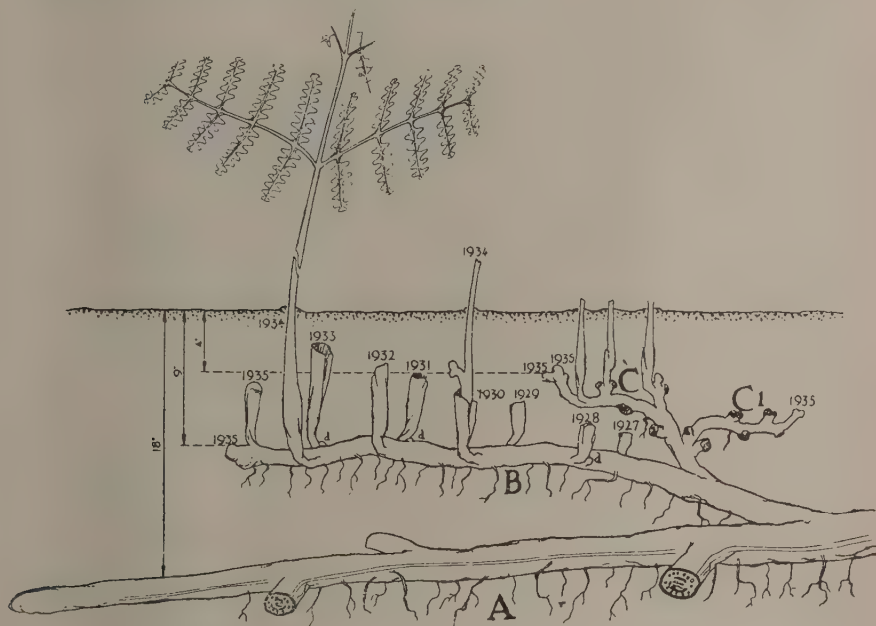
In Western Australia it is gradually occupying increased areas. Its incidence is greatest on those properties with the largest cleared areas and therefore it is easy to understand why more is not heard of the loss of country. In general it may be said that sufficient is known of the methods of control in this State to prevent it from becoming a serious pest on small well-worked properties.

A picture of this plant and its method of vegetative growth and aggression is best given in the words of K. W. Braid¹:—

"The bracken plant consists of a bulky underground system which extends for many dozens of square yards. Many a patch of bracken is in fact one extensive plant annually producing hundreds of fronds. Possibly even large bracken areas are all one plant, so it is obvious that the whole must be attacked as a unit. Under ideal conditions of good deep soil the subterranean system can be shown to be made up of three or more tiers of rhizomes or underground stems. The lowest tier—the leader—usually runs at a depth of 15 to 25 inches and is the main invading system. It possesses the thickest rhizomes ending in a terminal finger-like bud which periodically produces side buds to right and to left. This is figured in the diagram as A. The side buds develop into branches which bend upwards and move horizontally in a region above, and if they are within nine inches or less of the surface often bear fronds (B). They also produce subsidiary buds which grow into much thinner, shorter branches, often characteristically zigzagged (C and C1). These approach nearer to the surface and frequently produce fronds in groups. The proportions in which these tiers are produced depend on soil depth and texture and the food ingredients available. Given good friable soil of good feeding quality, tiers A and B are abundantly produced, while if conditions are such as to check these, C develops most. Near the periphery of an area A and B are most abundant and tier C commonest about the centre. If for any reasons the depth of soil decreases, as for example when the subsoil of a rock approaches within seven to nine inches of the surface, all these zones get compressed into one layer overlying the subsoil, but the downward tendency of the terminal bud on A is such that if it reaches deeper soil three or even four tiers will again be exhibited. In all cases the terminal bud of each tier is the most active growing bud. By the division of the terminal cell it gives rise to lateral buds producing either branches or fronds. These may produce buds which may lie dormant for some years. Normally the fronds of each season arise from the side buds immediately behind the terminal buds of tiers B and C, but sometimes subsidiary buds may also develop at the base of these.

"If the frond is destroyed in the green state, the bud destined for next season's frond begins to develop and in addition some of the dormant buds or subsidiary buds develop into fronds."

The fact that the rhizomes are in tiers at varying depths explains how the plant survives the heat of summer. Water in large quantities is needed to replace that lost by transpiration and this can always be obtained by the deepest rhizomes, and with this water it also obtains much mineral food.



BRACKEN: UNDERGROUND SYSTEM IN JANUARY.

A. Main elongating rhizome.

B. Large branch bearing fronds from near apex.

d. Dormant buds. The remains of 1934 fronds extend to surface; those of previous years in various stages of decay. In one case a branch from a dormant bud had grown through an old frond-base.

C. Branch of limited growth; fronds as in B.

Cl. Except at end only leaf-scars are depicted.

r. Roots.

From the Scottish Journal of Agriculture, April, 1935, p. 122.

"The bulk of the rhizome may be enormous, five or even ten or more feet of it lying below each square foot of surface. This is packed with food reserves such as sugars and starch. All these food reserves are manufactured in the fronds from the carbon dioxide in the atmosphere and the water and minerals absorbed from the soil.

"The removal of the fronds therefore (a) prevents the building up of further foodstuffs, (b) exhausts the underground reserves by inducing attempts to produce new leaves. Theoretically (and this is backed by experiment), the best time to destroy the fronds is when they have reached their maximum growth, *i.e.*, when they have drained the rhizome but have not begun to contribute food."

This statement agrees with the conclusions reached from observations in this State, that the optimum time for cutting is at the end of spring when the fronds have made full growth. There is always a smaller crop of young fronds after cutting at this time than after cutting at any other period of the year. Where two cuttings per year are carried out, one in October-November when the fronds are at full growth and another in May-June the depressing effect on the plants is greatest. Cuttings in January, February or March appear to have little effect in reducing the thickness of the succeeding crop. Cuttings from May to September result in a fairly large crop of young fronds, but when this is followed by another when the plant is at full growth a greater effect is obtained.

That the removal of the fronds will cause a depletion of the rhizomes is confirmed by examinations carried out by Smith (2):—

“When the rhizomes from the trial holes were examined, depletion of the larger storage rhizomes was evident. Those from an uncut area were large and plump and hard for large distances and only old parts showed decay. Rhizomes from the cut plots were shrunk from a short distance behind the growing point, and they contained a milky fluid instead of the firm white tissue of normal bracken.”

Hendrick³ showed by a series of analyses that the amount of food reserves as expressed by soluble carbohydrates and nitrogen, diminishes steadily up till the time of maximum growth of the fronds, after which there is again an increase.

The starvation of the root system is also demonstrated by the diminishing size of the fronds.

There can be no doubt that the cutting of bracken is the most effective method of attack, but unfortunately this method cannot always be economically applied.

An outline of the procedure which it is suggested should be followed is given hereunder. For convenience it is proposed to consider an area of partially cleared country and to follow its progress from a bracken infested area until it is an area of open pasture. A consideration of bracken in virgin country will not be made as in these conditions it cannot be described as a serious pest, and the method of attack necessary to subdue it would be an expensive one. Usually, however, the bracken does not assume the proportions of a pest until some preliminary clearing is carried out allowing more sunlight to reach the areas where the outpost plants are existing.

If it is impossible to commence clearing the area more thoroughly and it is necessary to attempt a reduction in the amount of the pest, the following methods may be applied.

Fire.—In areas such as those under consideration it is possible almost every year to get a fire to go through the paddock burning the dead bracken and at least killing the green fronds. It is more usual to burn every second or third year when a more intense fire and a cleaner result can be obtained. Experience has shown, however, that this method of control is totally ineffective as a means of eradication of bracken unless it is combined with certain other steps. It can only be considered as a method justified by expediency, inasmuch as the pest is not actually checked but the ground is cleared of the dry debris. As a consequence young grass is allowed a slightly more clear space in which to grow, and stock will be able to make their way more easily through the areas so treated. This method is of course usually restricted to large paddocks.

Pasture.—Good results have been obtained by sowing subterranean clover seed on the ashes after a burn as described above, and topdressing with superphosphate. The clover usually is able to make rapid development until such time as the bracken

growth and debris again is smothering the area and another fire is needed. This growth of clover entices stock into the area which then assist in counteracting the pest by their eating or trampling the young fronds.

Cutting.—A further step which is occasionally taken in conjunction with the above is the use of the fern hook to clear the area periodically. This entails either the gathering of the fern into heaps for burning or recourse to a running fire, to clear the ground. The employment of the fern hook will depend for its efficiency on the time of the year that it is used.

Subdivision.—While the methods referred to above will gradually open up the paddock, the erection of subdivisional fences will assist in speeding up the attack. The trampling effect of the stock by being localised will be more severe, and it will be easier to carry into operation a plan for more offensive methods.

Clearing.—The clearing of the stumps and fallen trees must be carried out before it can be hoped to fully subdue the fern. The ground is then ready for the plough, and it is usual to sow a crop of some sort in order to level the ground sufficiently for the use of the mower. As a means of subduing the fern the plough is not as effective when used before a period of cutting as it is when used after. The deepest rhizomes are untouched and remain vigorous to take up the attack. After a series of cuttings the higher rhizomes are weakened and the lowest which usually do not produce fronds commence to grow towards the surface so that the production of fronds may be continued. It can be easily realised therefore that a ploughing after a period of cutting will be much more effective in breaking up the whole of the rhizome system.

Mowing.—The ground after having been ploughed and cultivated will be in a level condition and fit for the use of a mower. The system of attack by cutting can then be carried out with this implement. Unfortunately the optimum time for doing this work coincides with one of the busiest periods on a farm, the harvest. That cutting at this period is effective is proved by the fact that the bracken does not survive if a paddock is cut two or three times for hay.

Old Pasture.—Where it is desired to reclaim old pasture which has been allowed to succumb to the advance of bracken, the method to be adopted will vary according to the density of the growth. Assuming the field to be densely covered it is suggested the best results would be obtained by following the steps suggested hereunder or variations thereof:—

- (a) clear the paddock of the accumulation of dead bracken by burning during the late summer.
- (b) If subterranean clover is not present sow on the ashes up to six pounds of inoculated clean seed or an equivalent amount of burr per acre, the rate depending on the original density of the bracken. Six pounds per acre will give a complete cover in the first season.
- (c) Fertilise with at least one hundredweight of superphosphate per acre.
- (d) Stock lightly, allowing the clover to seed.
- (e) Mow the paddock in November even if the hay crop be unsuccessful.
- (f) In the following autumn mow the regrowth of bracken, fertilise with superphosphate and allow stock to graze more heavily.
- (g) Close the paddock early and cut for hay.



Fig. 1.—Partially cleared country, rendered temporarily useless by a heavy growth of bracken.



Fig. 2.—A fully cleared hillside, completely covered with bracken. Clearing fires have not checked its growth.

The process of cutting twice annually should be continued for two seasons, when the densest bracken will have been severely checked. If preferred after two seasons' cutting, a crop could be sown and the ploughing necessary would be effective in cutting to pieces the weakened rhizomes, which would have been drawn closer to the surface.

Other Methods of Attack.

Whipping has been carried out in certain countries, particularly France. There does not appear to be any very definite information available as to its efficiency. There can be no doubt that the bruising effect particularly during the growing period would weaken the root system. As far as can be ascertained the comparative effects of cutting at the optimum time and whipping have never been studied.



Fig. 3.—Subterranean clover growing vigorously amongst bracken. The trampling of the stock has effected a great reduction in the density of the plants.

Rolling.—Much is claimed for the effectiveness of various types of rollers and drags. Some of these are fitted with chopping blades of different kinds. Rolling requires clean open paddocks free of stumps and fallen trees, and in these circumstances cannot be more successful than the mower. Further, the best time to use the roller is when the fronds are young and brittle. This allows a later growth of fronds in the same season and so a series of rollings would be required.

Pigs.—The use of pigs that have not been nose rung is quite successful. The animals like the succulent roots and will turn over much ground in order to reach them. It is obvious however that their use on a large scale for this purpose is not practicable.

Weedicides.—Much more promise is attached to the possibility of attack with weedicides. As the clearing of bracken is undertaken primarily to allow utilisation

of the ground for other plants, the selection of a weedicide is limited to those which, while destroying the plants will not injure the soil. Among the substances capable of performing the work the chlorates of sodium and calcium are the most useful. It has been demonstrated by Braid and others that it is possible to get a complete kill, of both fronds and roots by a single application of sodium chlorate. For this



Fig. 4.—Bracken being beaten back from pasture. In the foreground the clear space has been mown for hay during the past two seasons. The headland along the fence is still carrying vigorous plants. In the background the fern has been cut by the mower.

purpose a dressing of not less than two hundredweights per acre is required. As the chemical is high in price this method is, temporarily at least, prohibitive. Another system is the application of sodium chlorate direct to the cut stalk of the frond by the use of a piece of sponge rubber saturated with a solution of the chemical, attached to the blade of a scythe or to the cutter bar of a mower. This system is claimed to be fully effective and uses only a small amount of the chlorate. As the cost should be of a range to allow of its adoption on a wide scale, arrangements are being made to carry out trials in this State.

References:—

- ¹ K. W. Braid—'Scottish Journal of Agriculture,' Vol. XVIII., No. 2.
- ² W. G. Smith—Trans. Bot. Soc., Edinburgh.
- ³ J. Hendrick—Kew Bulletin, No. 4, 1921.

SOME EFFECTS OF GREEN MANURING ON CITRUS TREES AND ON THE SOIL.

I.—INTRODUCTION.

In 1924, a permanent green manure experiment was begun in a newly-planted citrus orchard at the Commonwealth Research Station, Griffith. The purpose of this Bulletin is to report the results that have been obtained concerning the effect of various treatments on the growth and yields of the trees and on the fertility, structure and water-holding capacity, the moisture content, and irrigation requirements of the soil.

SUMMARY.

This Bulletin reports the results of a green manure experiment over a period of thirteen years with citrus trees at the Commonwealth Research Station, Griffith, New South Wales.

The growth of a winter green manure crop (tick beans) increased the growth and yield of trees compared with trees kept clean-cultivated.

The growth of a summer green manure crop (cowpeas) at first decreased the growth and yield of the trees owing to the competition of the cowpeas for soil moisture during the summer. After about ten years the trees on the cowpeas plots caught up to those on the clean-cultivated plots. The better growth of the trees in the cowpeas plots compared with those of the clean-cultivated plots, in later years, is due to the decline in fertility and loss of structure of the soil of the clean-cultivated plots, combined with the fact that the cowpeas do not offer such strong competition to mature trees as to young trees.

The growth of lucerne offers very strong competition to trees, and the growth and yield of trees on the lucerne plots are greatly reduced.

A marked seasonal cycle of soil nitrate concentration occurs on both the tick bean plots and clean-cultivated plots, the seasonal cycle being significant to 120 cm. deep in the tick bean plots but disappearing after 60 cm. in the clean-cultivated plots.

Rains and irrigation cause minor fluctuations in concentration of soil nitrate. The tick bean plots contain a higher annual mean nitrate content in the surface soil than the clean-cultivated plots; but the reverse is true at the lower depths. Throughout the whole profile to 120 cm. depth, the clean-cultivated plots have the highest nitrate content.

When tick beans are ploughed in before September, little decomposition takes place and nitrates do not increase until the beginning of this month. Early September seems the best time to plough under the tick beans.

The presence or absence of the citrus trees has little effect on the seasonal soil nitrate concentration cycle.

When tick beans are ploughed under, there is a rapid formation of ammonia in the surface mulch, and this persists throughout the early summer.

On the irrigated soils of the Murrumbidgee Irrigation Areas, concentrations of nitrates to the order of 10 to 20 p.p.m. are commonly found down to 100 cm. or more.

During growth, the green manure depresses the water table.

The increase in the water-holding capacity of the soil after several years' green manuring is statistically significant but practically unimportant. The green manure has, however, a marked effect in preventing or reducing the loss of structure of the soil that is noted in the clean-cultivated plots.

The relation of green manuring to the fertility of the soil is discussed.

[Extract from Bulletin No. 120 of the Council for Scientific and Industrial Research.]

THE COMPOSITION OF CAPEWEED (*Cryptostemma calendulaeum*) FROM MECKERING AND BEVERLEY.

A. B. BECK¹ and R. G. LAPSLEY.²

During the investigations of toxic paralysis carried out over the past three years, it has been noticed that with sheep, the occurrence of depraved appetite, and hence of toxic paralysis, is definitely associated with a low plane of nutrition due to the poor quality of the summer grazing. At Meckering, where the toxic paralysis investigations were carried out, the main plants of unimproved pastures are capeweed, silver grass and cluster clover. The analysis of the capeweed samples was undertaken to see if there was any abnormality in the chemical composition which might be correlated with the development of depraved appetite. For the purpose of comparison, plants were also analysed from the Avondale Research Station, Beverley, an area of heavier soils and better pastures, where depraved appetite is unknown. The work was also undertaken as a part of a wider investigation. Owing to the short growing season in the wheat belt areas, the natural pastures consist entirely of early maturing annuals. The quality of these pastures is of the greatest importance, in that the dry feed which the sheep receive in the summer is usually composed entirely of the dry residues of annual plants which have grown during the winter and spring. As a continuation of the pasture investigations commenced between 1933 and 1935 (Underwood, Shier, and Harvey, this Journal, December, 1937, page 442), it is the intention of the Animal Nutrition Branch to carry out a "long range" investigation of the subject in order to provide a basis on which to improve our pastures, and so to improve the nutrition of our sheep.

Samples were taken at intervals of from three to four weeks so as to ascertain the changes in composition during the growing season.

The samples from Meckering were obtained from a large paddock of about 100 acres in the Research Station property; half of this paddock had been cleared and cropped in past years. In the cleared area, from which all the samples were taken, there were two distinct soil types, a red sandy loam which comprised the larger part of the area, and also a small area of 4.5 acres of deep, grey sand. Normally when sheep were running in this paddock they had access to both areas. The capeweed was the main plant in the sand area, and was more sparse, although larger, on the loam. Except where specified to the contrary in the following tables, the sample analysed was a composite sample taken from both areas.

At Beverley two series of samples were taken. The first was from around an oat crop on typical York gum soil; this, as is usual, formed a large succulent growth and probably represents the best type obtainable. The second series was obtained from a paddock under grazing. This paddock was of a more sandy type of soil than that of the oat crop, and because of this and the grazing the plants kept quite small.

The sample from Merredin was taken from the typical heavy salmon gum and gimlet soil at the Research Station.

Experimental Methods.

The collection, sampling and analysis of the samples presented many rather peculiar problems, and standard methods had to be more or less arbitrarily adapted for this work.

The sample for analysis was obtained by picking a large number of plants from the area concerned until a sample of one to two lbs. green weight was obtained. The plants were picked up at random places over the area and were selected as average samples from that particular place.

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² Agricultural Adviser assisting in toxic paralysis investigations.

Samples were obtained by cutting off whole plants with curved scissors just above the ground. In most cases capeweed grows close to the ground and the dense felt of hairs on the back of the leaves collects and retains the sand from the soil with great tenacity. Sieving the dried plants does not remove this sand, so for all the samples prior to the commencement of flowering, the plants were washed to remove the sand. It is realised that this procedure is open to the objection that there will be a certain loss of cell sap by diffusion, but as the washing only takes a very short time, it was considered that the error from this cause would be very small and certainly very much less than the error caused by the presence of the sand.

After washing, the plants were allowed to air dry to as near as could be judged to their original condition and then weighed in order to give their original moisture percentage. The samples were then dried at 60-70° C. and then allowed to come to an "air-dry" condition for crushing and analysis.

The earlier samples were crushed in a small coffee mill, but later a Wiley mill was installed and this was then used. In some cases during the air-drying process after oven drying, the plants took up so much moisture that it was necessary to use dried samples for crushing. In both types of crushing there was a certain amount of segregation of the woolly fibres from the back of the leaf, but with the product from the Wiley mill this was small.

Standard methods of analysis were used. "Moisture" is the loss on drying at 100° C. overnight. Ashing was done at a dull red heat, and the portion insoluble in 1:1 hydrochloric acid was termed "insoluble ash" (see later). The "ether extract" was done on moisture-free samples using ethyl ether. The crude fibre was filtered on a No. 54 filter paper. The appearance of the "crude fibre" from the younger samples was quite remarkable, the fibre consisting of the hairs from the back of the leaves and appearing as a felt-like mass. Phosphorus was determined volumetrically and in some cases colorimetrically as well; the agreement was not always as close as might be desired.

As is seen in the following table the "insoluble ash" of some of the samples is quite high. A microscopic examination of the product suggested that it consisted entirely of coarse sand grains, and so it was decided to correct all the analytical figures for this sand, using the assumption that the "insoluble ash" was entirely adventitious sand. This assumption is open to two possible errors; firstly the "insoluble ash" may contain plant silica, this is considered unlikely as the appearance of this ash showed nothing but sand and further an analysis showed that the "soluble silica" of capeweed ash is very low (about 1 per cent. of the total ash). The high base content of the ash would further tend to give acid soluble silicates during ashing. The second objection is that the insoluble ash may represent a part only of the adventitious sand and clay, as the high alkali would tend to convert the finer portions of these into soluble silicates. This objection, however, is not considered to be serious and it is considered that the method of tabulation of results will probably give the truest picture of the composition of the plants. Another reason in favour of this method is that the presence of coarse sand in the lighter capeweed makes sampling very difficult and even if the sand content varies the corrected figure will be unaltered.

In the following tables the "moisture" figure is of the sample as collected from the field, corrected for "insoluble ash." The "insoluble ash" figure is for the sample actually analysed, calculated on a moisture-free basis. All other figures are for the "moisture-free assumed ash" basis. These have been calculated from the actual analytical figures (moisture-free) as follows:—

$$\frac{\text{"moisture-free assumed ash" figures}}{\text{figures}} = \frac{\text{actual analytical "moisture-free" figures}}{\text{figures}} \times \frac{100}{100 - \% \text{ "acid insol." ash actual dry basis.}}$$

As an example of the method of calculation, Sample No. 100 as analysed contained 13.3 per cent. moisture, 3.0 per cent. insoluble ash and 20.6 per cent. crude protein. Correcting these for moisture, the insoluble ash and protein then become 3.5 per cent. and 23.8 per cent. respectively. To correct the protein figure for the insoluble ash it is multiplied by $\frac{100}{100 - 3.5}$; the protein content on a "moisture free assumed ash" basis then becomes 24.7 per cent.

In all cases except where specified to the contrary the analyses refer to whole plants collected as previously described.

TABLE 1.
MECKERING.

Date.	Sample No.	Moisture.	Assumed Ash Dry-Basis Figures.							Insol. Ash.	Remarks.
			Crude Protein.	Ether Extract.	Crude Fibre.	N.F.E.	Assumed Ash.	CaO.	P ₂ O ₅ .		
8-6-37	77	92.6	27.5	3.8	13.2	39.3	16.2	2.15	0.55	1.4	Specially selected; ungrazed; best growth available.
2-7-37	89	93.8	30.2	4.9	13.9	32.1	18.9	1.75	0.98	2.2	
28-7-37	97	89.7	17.2	4.4	13.9	49.2	15.3	1.87	0.70	0.2	Sample from red loam area only.
17-8-37	132	86.5	11.4	3.0	13.0	62.1	10.5	1.79	0.43	0.6	
17-8-37	133	86.9	11.5	3.3	14.5	59.8	10.9	1.42	0.36	1.3	Sample from grey sand area only.
31-8-37	140	82.1	7.9	2.4	12.7	68.1	8.9	1.58	0.48	3.6	Some flowers out; many flowering heads.
13-9-37	142	84.2	8.0	3.7	14.4	65.6	8.3	1.65	0.65	2.9	In full flower; bottom leaves drying off.
29-9-37	152	81.0	6.9	6.0	19.3	57.0	10.8	2.14	0.50	1.7	Leaves drying; still in flower. No seed heads shed.
13-10-37	160	79.8	5.9	4.9	22.7	54.7	11.8	2.14	0.35	1.9	Flowering finished; many seed heads, large proportion shed; bottom leaves dry.
3-11-37	169	10.0	6.2	5.4	25.2	57.8	5.4	2.34	0.32	6.6	All dry.
31-8-37	139	84.8	10.6	5.5	14.7	60.1	9.1	1.76	0.71	1.9	Flowers with about $\frac{1}{2}$ -in. stalk; badly infested-red mite.
13-10-37	161	82.7	11.2	5.0	15.9	59.3	8.6	1.55	0.68	0.5	Flowers; all small.
Nov., 1936	176	7.5	13.2	....	....	....	....	1.41	1.22	....	Seeds.
13-10-37	162	10.4	11.3	3.9	....	....	8.4	1.53	0.97	0.7	Seeds.

Other analysis—No. 97: K₂O 3.45; Na₂O 2.74; MgO 0.59 per cent.

TABLE 2.
BEVERLEY OAT CROP SAMPLES.

Date.	Sample No.	Moisture.	Assumed Ash Dry-Basis Figures.							Insol. Ash.	Remarks.
			Crude Protein.	Ether Extract.	Crude Fibre.	N.F.E.	Assumed Ash.	CaO.	P ₂ O ₅ .		
22-7-37	91	93.1	25.1	4.8	16.4	37.2	16.5	1.34	0.67	0.1	Stalks cut off largest samples.
13-8-37	100	92.7	24.7	4.0	14.6	42.5	14.2	1.63	0.71	3.5	
30-8-37	137	92.9	16.5	3.9	17.8	44.4	17.2	1.50	0.59	0.2	Contained a few flowers.
16-9-37	150	91.0	15.2	5.7	16.7	48.2	14.2	1.69	0.43	0.4	A few flowers in sample.
6-10-37	156	89.7	10.2	7.2	19.0	46.9	16.7	2.21	0.38	0.2	In flower.
19-10-37	165	87.4	10.0	3.5	20.6	50.3	15.6	2.00	0.35	1.2	A few flowers, but mostly seed heads with seeds; bottom leaves showing slight signs of drying off.
8-11-37	174	86.7	5.8	5.3	27.9	47.2	14.0	2.11	0.55	5.3	Stems moist, leaves dry.
23-11-37	177	7.2	6.5	3.8	27.0	50.0	12.7	2.70	0.31	1.7	Plants quite dry.
16-9-37	149	86.6	26.8	3.6	16.4	44.7	8.5	1.37	0.74	0.2	Flowering heads and about 2 in. stalk only.
19-10-37	164	8.8	11.1	....	....	....	6.3	1.74	0.91	0.1	Seeds only.

Other analyses—No. 137: MgO 0.60 per cent.

No. 100: Na₂O 3.50 per cent.; K₂O 4.86 per cent.

TABLE 3.
BEVERLEY STUBBLE PADDOCK SAMPLES.

Date.	Sample No.	Moisture.	Assumed Ash Dry-Basis Figures.							Insol. Ash.	Remarks.
			Crude Protein.	Ether Extract.	Crude Fibre.	N.F.E.	Assumed Ash.	CaO.	P ₂ O ₅ .		
21-5-37	76	93.1	26.0	4.3	14.4	37.7	17.6	1.85	0.88	9.6	
24-6-37	86	92.5	27.0	4.7	14.8	36.7	16.8	2.50	0.73	4.1	
22-7-37	96	88.8	17.0	4.2	15.8	49.7	13.3	2.22	0.55	3.1	Showing slight signs of grazing.
13-8-37	99	86.8	12.2	3.3	11.2	58.1	15.2	2.15	0.60	0.5	Not grazed recently; flower heads showing.
30-8-37	138	85.7	9.5	3.4	15.0	62.1	10.0	1.90	0.50	3.7	Some plants showing signs of grazing.
16-9-37	151	86.8	9.4	3.5	16.4	62.2	8.5	2.14	0.55	3.7	Plants all flowering.
6-10-37	157	86.9	10.3	4.9	18.4	55.5	10.9	2.16	0.47	1.3	
19-10-37	163	70.2	6.2	3.5	21.2	58.4	10.7	2.71	0.42	11.5	Most seed heads empty; bottom leaves dry.
8-11-37	175	24.0	5.7	4.5	23.5	56.9	9.4	2.40	0.45	9.4	Apparently all dry.

Other analyses.—No. 99: K₂O 2.18 per cent.; Na₂O 1.72 per cent.

MERREDIN SAMPLE.—No. 135, 27-8-37: Moisture 90.4 per cent, Crude Protein 19.8, Ether Extract 3.1, Crude Fibre 12.2, N.F.E. 50.5, Assumed Ash 14.4, Insoluble Ash 1.1, CaO 1.88, P₂O₅ 0.64, MgO 0.66 per cent.

Discussion of Results.

The analyses of the Meckering plants show no abnormality which would account for the development of depraved appetite in this area.

The most prominent feature of the analyses is the very high water content of the plants, which persists up to the time of flowering. This high moisture content probably explains the scouring and also the loss of weight that the sheep undergo when on the first green feed at Meckering. If the pasture were pure capeweed containing 92 per cent. water it would be necessary for a sheep to eat 25 lbs. green weight to obtain a dry matter intake of 2 lbs. The sheep apparently leave the dry grazing once the green feed appears and the sparseness of the growth of the early green feed makes the loss of weight easily understood.

If, however, we consider the dry matter only it is obvious that for the greater part of the season capeweed is a high quality feed. The high protein content in the early growth is quite outstanding and, even in the dry plants after the seeds have been shed, the percentage of protein is as high or even higher than that of average wheaten chaff. Up to the time of drying off the fibre content is relatively low and even in the most fibrous sample (No. 169) can hardly be regarded as excessive.

The assumed ash forms a high percentage of the dry matter. It should be remembered that, in the samples analysed the bulk of the adhering sand has been removed, whereas in the case of the material eaten by the animal the product will usually contain a relatively high percentage of sand. The percentage of sand is greatest in the young growth, particularly after rain.

The high percentage of calcium, sodium, and potassium contribute further evidence against any suggestion that depraved appetite in sheep might be due to acidosis caused by alkali deficient foods. The calcium content is high and the increase of calcium content in the older samples is worthy of notice. In most samples the phosphorus content tends to be on the low side as judged by overseas standards.

It is hoped at a later date to do a feeding trial with some sheep using dry capeweed alone and thus to obtain further data on the feeding value. In many parts of the Western Australian wheat belt capeweed is apparently regarded as a valuable fodder. The rapid early growth makes it valuable as a first green feed even although it causes scouring. It is regarded as a fair to good feed during growth, but not fattening until it has dried off somewhat. These observations are strongly supported by the analytical data which indicate that the high moisture content give it

a low feeding value in the green state, but on a dry basis it should be regarded as a fairly high quality feed.

As a contrast to Western Australian experience it is interesting to note that in South Australia capeweed is generally regarded as being unpalatable to sheep.

It is probable that the main advantage of capeweed as a pasture plant lies in the fact that it can flourish under conditions which prohibit the growth of better quality pasture plants. Although it has many advantages as a pasture plant, particularly for lighter soil areas, it also has several distinct disadvantages.

There is no evidence that the felt-like hairs or fibres on the back of the leaves cause any digestive troubles, but in some localities the internal fibres of the leaf and stem get between, and loosen the teeth of the sheep. The very succulent nature of the growth results in a low yield of dry matter per acre and the bulkiness of the plants enables it to crowd out more desirable species. When dry the capeweed tends to break up and blows away easily. Another important disadvantage has been suggested by the observations of Mr. K. R. Norris (private communication) which support the contention that capeweed favours the increase of Earth Mite (*Halotydeus destructor*, commonly known as red mite).

Although capeweed forms the bulk of the grazing on the lighter soils of the wheat belt and the analyses show that, on a dry basis, it is of good quality, yet, taking all facts into consideration it cannot be regarded as a good pasture species. Pasture improvement, including the introduction of legumes such as early subterranean clover, should do much to improve the present low-producing capeweed pastures in the better rainfall areas of the wheat belt.

AGRICULTURAL PROBLEMS.

Agriculturists, pastoralists and primary producers generally, who may be having difficulties of any kind in connection with their production activities, are invited to communicate with the Agricultural Adviser of their district of the Department of Agriculture, when information and advice will be supplied free of charge.

Where identification of plant or stock diseases or insect pests is required, full details of symptoms should be forwarded and also samples of the diseased plant, animal tissue or insect where practicable. Plant tissue intended for examination by the Plant Pathologist should be wrapped in paper and not forwarded in airtight containers, and plant specimens for the Botanist should be pressed between newspaper and dried before despatch. With regard to animal tissue for microscopic examination, this should be forwarded in a solution of 10 per cent. formalin, or if of considerable bulk in a sealed kerosene tin containing a few ounces of formalin as a preservative. Living insects should be sent in suitable containers and dead specimens in methylated spirits.

The addresses and names of Advisers are as follows:—

Albany	...	...	...	H. R. Powell (Fruit); B. Williams (Dairying).
Bridgetown	...	...	...	A. Flintoff (Fruit); A. M. Tindale (Dairying).
Bunbury	...	...	...	M. Cullity.
Geraldton	...	...	...	N. Davenport (Government Buildings).
Gosnells	...	...	...	R. C. Owen.
Harvey	...	...	...	R. L. Cailles (Fruit).
Katanning	...	...	...	A. S. Wild.
Kalamunda-Roleystone	...	...	...	W. H. Read, c/o. Department of Agriculture, Perth.
Kununoppin	...	...	...	W. M. Nunn.
Manjimup	...	...	...	C. M. Scott.
Metropolitan, Gingin, Chittering	...	...	...	S. E. Bennett, c/o. Department of Agriculture, Perth.
Mundaring	...	...	...	V. Cahill.
Narrogin	...	...	...	A. T. Gulvin.
Vasse	...	...	...	J. M. Nelson.

DIPPING OF FLOCKS. *Ind.*

By HUGH MCCALLUM,
Sheep and Wool Inspector.

The only satisfactory method for eradicating ticks and lice is by dipping. This is an essential routine practice and must be carried out to obtain maximum value for the clip.

Tick and lice are blood sucking insects and the amount of damage done depends on the extent of infestation. They cause intense irritation which the sheep attempt to allay by rubbing on fences and logs and biting at the seat of irritation. The natural consequence is that the sheep are unsettled, go off their feed and lose condition. The damage is most apparent in the wool and patches of skin may even be denuded; therefore, besides actual loss of wool, there is also a lowering of the wool's value.

The following rules should be noted by the farmer:—

- (1) Do not dip in extremely hot or cold weather.
- (2) Do not dip thirsty, hot or overfed sheep. The sheep should be cooled off and completely rested before dipping.
- (3) Commence dipping early and finish at least two hours before sundown to allow the sheep to dry off.
- (4) Every animal should be completely immersed once.

All farmers should be aware of the regulations concerning sheep dipping in this State.

Information on sheep dipping can be obtained from this Department free of charge.

ALL-AUSTRALIAN EXPORT BACONER AND PORKER CARCASE COMPETITIONS.

The above competitions will be continued during next year when judging will be held in London in June. Entries for this series will be due at Australian works on 15th April, 1939.

The competitions were started mainly to provide a means of acquainting Australian pig raisers with the requirements as to type and conformation of the United Kingdom market, the only overseas outlet for our surplus pork. Australia's share of that market has increased steadily over recent years and to enable us to continue to compete it is essential that the requirements of United Kingdom consumers should be met. Prices are at present very good for the Australian supplier and, as supplies are regulated, are likely to remain so.

Carcases entered for the competitions are judged in London according to a system of measurements and photographs devised by Dr. John Hammond and other English authorities. Marks are awarded for various features such as body length, leg length, hams, shoulders, etc., and a full list of these marks is supplied to each entrant to enable him to see how far and in what respects his pigs fall short of the ideal.

Apart from the prospects of success in winning a prize—a sum of £25 is distributed in prizes in each section—the competitions thus offer a valuable service to all entrants.

Entry forms may be obtained from works which treat pigs for export, from the Departments of Agriculture and the Veterinary Officers of the Commonwealth Department of Commerce in each State and from the office of the Australian Meat Board at 401 Collins Street, Melbourne.

ELECTRICAL STERILISING OVENS.

Description of an Instrument Suitable for Dairy Bacteriology Laboratories.

By H. H. KRETCHMAR, B.Sc., A.A.C.I., Dairy Bacteriologist.

From certain information which has been brought before the notice of the writer, it is understood that difficulty has been experienced in obtaining ovens suitable for sterilising certain portions of the equipment often used in the routine methods of some dairy bacteriology laboratories. In consequence, the following description of the method of design carried out by the writer is offered in the hopes of its being useful in this connection.

The apparatus in order to meet the requirements of the writer's laboratory, had to fill the following requirements:—

1. Produce an even heating over the whole of the internal space.
2. Attain its working temperature within a reasonable period of time.
3. Maintain the working temperature with a minimum of adjustment.
4. Produce but little rise of temperature in the laboratory when installed. (The summer temperature in Perth is comparatively high).
5. Have sufficient length to accommodate milk sampling tubes or "thiefs" of a maximum length of 30in.
6. Possess sufficient space for 4 dozen milk sampling tubes together with an equivalent number of 1 oz. sample bottles.
7. Accommodate the usual other bacteriological apparatus such as Petri dishes, pipettes, etc., on suitable shelves.

To meet the above requirements as regards space for accommodating the various apparatus, it was decided that the internal dimensions should be, length 33in., diameter 12in. Also, brackets to carry three perforated shelves, evenly spaced, were decided upon. A circular cross section was chosen for the shape of the chamber because of ease of fabrication, particularly as regards the disposition of the heating windings.

To provide adequate heat insulation a 3in. packing with slag wool, distributed evenly on all surfaces in order that even heating of the interior would be maintained, was deemed advisable.

In the design of the heating element two factors must be taken into consideration; the power consumption and the temperature at which the element is to work. By interpolation from the designs of standard commercial ovens manufactured for other purposes, the element was designed to dissipate 440 watts and this power expenditure has proved most suitable.

From this stage forward the design is governed by the voltage of the power supply. As an example, an oven designed and built for the dairy laboratory at the Muresk Agricultural College, where the power supply has a voltage of 220 volts, will be described. As the element must dissipate 440 watts and the power voltage is 220 volts, the current the windings must carry is $440/220 = 2$ amperes. In order to limit the current to this figure the resistance of the winding must be $220/2 = 110$ ohms.

The temperature at which the wire is to work next requires consideration. For sterilising purposes the oven is required to work at a temperature of 170° C. When the oven is running at this temperature and the wire is producing just sufficient heat to make good the loss of heat from the oven to the atmosphere, it should be obvious that, with the winding close to the internal shell of the oven and heavily heat insulated externally, it should have, ideally, a temperature of approximately 170° C.

CHARACTERISTICS OF NICHROME WIRE.

Gauge: B. and S.	Diameter :		Resistance per 1,000 :		Weight per 1,000 :		Stretched free : Ampères to give a temperature centigrade of :								
	Inches.	Mms.	Feet. Ohms.	Metres, Ohms.	Fect. (lbs.)	Metres. Kilos.	100°.	200°.	300°.	400°.	500°.	600°.	700°.	800°.	900°.
18	.040	1.023	412	1,353	4.42	6.60	3.26	5.95	8.13	10.1	11.8	13.6	15.1	16.8	18.4
19	.036	.911	509	1,669	3.58	5.20	2.76	5.04	6.88	8.60	10.1	11.55	12.8	14.2	15.6
20	.032	.810	645	2,115	2.83	4.23	2.32	4.27	5.83	7.30	8.53	9.70	10.85	12.0	13.2
21	.0285	.723	813	2,667	2.24	3.34	1.97	3.62	4.94	6.17	7.23	8.21	9.20	10.2	11.2
22	.0253	.643	1,031	3,382	1.77	2.64	1.67	3.07	4.18	5.23	6.13	6.96	7.80	8.65	9.46
23	.0226	.574	1,292	4,237	1.41	2.10	1.42	2.60	3.54	4.43	5.19	5.90	6.61	7.33	8.02
24	.0201	.510	1,634	5,360	1.12	1.67	1.20	2.20	3.00	3.75	4.40	5.00	5.60	6.20	6.80
25	.0179	.454	2,060	6,757	.89	1.33	1.02	1.86	2.54	3.18	3.73	4.25	4.67	5.27	5.76
26	.0159	.403	2,611	8,564	.70	1.02	.865	1.58	2.15	2.70	3.16	3.61	3.96	4.47	4.88
27	.0142	.360	3,274	10,739	.56	.84	.734	1.34	1.82	2.28	2.68	3.06	3.36	3.80	4.13
28	.0126	.320	4,159	13,641	.44	.65	.622	1.13	1.54	1.85	2.27	2.62	2.86	3.23	3.50
29	.0113	.287	5,168	16,951	.35	.52	.527	.960	1.305	1.57	1.93	2.22	2.45	2.71	2.97
30	.0100	.254	6,600	21,648	.276	.41	.476	.814	1.105	1.33	1.64	1.89	2.08	2.30	2.52
31	.0089	.226	8,333	27,332	.219	.326	.378	.680	.935	1.13	1.39	1.60	1.77	1.95	2.14
32	.0080	.203	10,313	33,826	.177	.263	.321	.577	.791	.955	1.18	1.36	1.50	1.66	1.81
33	.0071	.180	13,098	42,961	.139	.207	.272	.490	.670	.809	1.00	1.15	1.28	1.41	1.53
34	.0063	.160	16,623	54,523	.110	.164	.231	.416	.567	.685	.849	.980	1.06	1.18	1.29
35	.0056	.142	21,019	68,942	.087	.130	.196	.353	.480	.580	.720	.830	.900	1.00	1.09
36	.0050	.127	26,400	86,592	.069	.103	.166	.300	.406	.491	.611	.704	.765	.850	.924

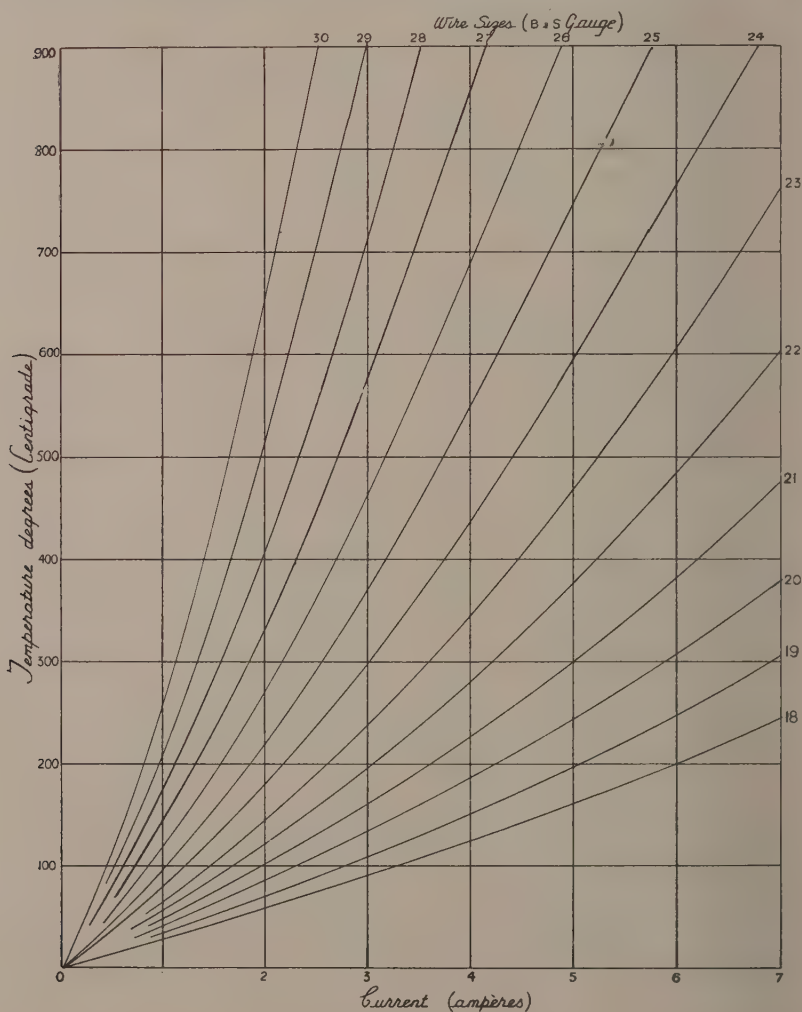
Comparison of resistance with change of temperature :—

20° C. = 1 Ohm ; 100° C. = 1.0185 Ohm ; 200° C. = 1.0417 Ohm ; 300° C. = 1.0645 Ohm ; 400° C. = 1.0828 Ohm ; 500° C. = 1.0928 Ohm ;
 600° C. = 1.0960 Ohm ; 700° C. = 1.1022 Ohm ; 800° C. = 1.11221 Ohm ; 900° C. = 1.1257 Ohm.

The tables published by the various manufacturers setting out the characteristics of the resistance wires they manufacture, give only the current required to maintain the wire at stipulated temperatures when the wire is straight, horizontal and free to radiate. However, the writer's experience has been, that for apparatus working at low temperatures, such as low temperature-ovens, the data contained in such tables may be satisfactorily utilised by assuming an increase of temperature of about 50 deg. C. over the temperature shown in the Table for the type of insulation described.

The wires used for heating purposes by the writer are made of the nickel-chromium alloy known as "nichrome" for which the characteristics of useful gauges are given in the Table.

A few of the temperature characteristics shown in the aforementioned Table have been shown graphically on the following chart in order that correlations may be made between other current values and temperatures.



To return to the problem under discussion, it is necessary to choose such a gauge of wire as will attain a temperature of approximately 170 deg. C. when carrying a current of 2 ampères. From the chart it may be seen that a suitable size of wire is 22 gauge, for when carrying 2 ampères and radiating freely the temperature attained is 120 deg. C. which, together with the assumed increase of 50 deg. C. when enclosed as discussed above, brings the working temperature to 170 deg. C.

The inner shell of the oven as finished is 36in. long by 12½in. diameter. It is constructed of 20 gauge rolled sheet iron and has one end welded in place to form the back end of the oven. To strengthen the open end or front of the oven, a strengthening ring of steel is placed around it at 3 in. from the front end. Brackets, disposed as described above, are riveted inside and the completed shell tinned all over.



For the purpose of insulating the winding from the shell, the latter is covered with bonded mica insulating sheet ("micaite"), which is tied in place with string until the windings are in place. It might be thought that the use of such material for insulating purposes is risky because of the chance of breakdown of the bonding when subjected to the heat of the oven. However, no difficulty has been experienced from this cause.

To secure the ends of the winding, electrical two-line porcelain connecting blocks are utilised. A piece of strong wire is looped through two holes in the wall of the oven, the two ends of it passed through one of the metal junction tubes in the connecting block and fixed in place by the small grub screws. The end of

the winding to be secured is passed through the metal junction tube not utilised for fixing purposes, and held securely by the grub screws. In order that the leads to the winding may not foul the tubes used for accommodating thermometers, the porcelain blocks should be placed slightly to the side of the line running along the top of the oven. Three of these blocks are required, two fixed at positions 3 in. in from the front edge of the inner shell and the other fixed close to the back edge.

Some device must be provided to avoid the turns of the winding short-circuiting when they become loosened by the heating current. The writer uses a number of lengths of asbestos cord bound to each end of the inner shell by a turn of strong wire. They are fixed to the back end of the shell before starting the winding, inter-twined with the winding as the latter is put into place, and finally bound with another turn of strong wire at a distance of three inches from the front end of the shell, at which position the winding ends. The lengths of cord are so arranged that each length passes over one turn of wire and under the next and the various lengths pass alternately under and over the same turn of wire. Illustration on previous page shows a shell with winding in position.



The winding is put on in two equal lengths, the turns of one length between the turns of the other length. Both windings end at the one binding block at the back of the oven, but at separate blocks at the front of the oven. Adequate lengths of wire must be left attached to the ends of the windings for making connection to a series-parallel switch mounted on a piece of insulating fibre at a position half way along the top line of the outer shell. To insulate the connecting leads they may be passed through a number of 6 in. lengths of small bore glass tube. To compensate for the extra radiating surface at the end of the oven the turns may be placed a little closer together at these positions.

The outer shell of the oven is also made from 20 gauge sheet iron. The length is 39 in.; the diameter 17½ in. For strengthening purposes, two channels are rolled into it at positions 9 in. and 30 in. from the front. Two sets of legs, the shape of which may be seen in the illustration above, constructed of 1 in. x ¼ in. rolled steel, are riveted positions 7 in. from the front and back ends. It is tinned all over.

The inner shell is held co-axially in the outer shell by an annular ring which has both edges flanged. The surface of the ring is tinned. The outer flange fits

tightly over the edge of the outer shell to which it is bolted by $\frac{1}{4}$ in. bolts and nuts. For ease in fixing, the nuts should be soldered over the bolt holes and on the inner surface of the outer shell. The diameter of the hole in the ring being 13 in., an annular space $\frac{3}{4}$ in. wide is left between the inner flange and the inner shell of the oven. This space is packed with sheet asbestos, forced into place, so that the only metallic connections between the inner shell and outer shell are the bolts used for fixing purposes. Eight quarter-inch countersunk-head nuts and bolts are used with the head of the bolt countersunk into the inner shell of the oven so that a free opening is left for the entry of the door.

The best procedure to adopt when assembling the oven is to bolt the annular ring to the inner shell (complete with its windings) as it stands on its back end, and then insert the inner shell into the outer shell as the latter stands on its back end. The two shells may then be fixed permanently together by bolting the annular ring to the outer shell. Nuts and bolts $\frac{1}{4}$ in. diameter are used for the purpose. The oven is next placed on its front end, the insulating glass sleeves passed over the electrical leads, and the latter taken through holes in the top of the outer shell to the three-heat (series-parallel) switch. The fitting for making connection to the supply circuit is mounted alongside the switch. The fibre baseboard is conveniently fixed to the top of the oven by bolts screwed into thick nuts soldered to the upper surface of the oven. The tubes to accommodate the thermometers are placed in position in holes which have previously been made at points spaced evenly along the top of the oven. The slag wool packing is carefully tamped into position so as not to displace any windings or connections. When the packing is all in place the back end, which has been tinned and has a flanged edge, is bolted in place. As with the front annular spacing ring, the bolting down is facilitated by first soldering the nuts in place over the bolt holes on the inside of the shell. Eight nuts and bolts are required.

The lid is constructed in two parts. One part, which forms the outside of the lid, consists of a tinned iron disc 12 $\frac{1}{4}$ in. diameter with a flanged edge $\frac{1}{2}$ in. deep. The disc holds two asbestos discs of $\frac{1}{4}$ in. thickness. The other part of the lid, which in use slides into the oven, consists of a shallow tinned pan 12 $\frac{1}{4}$ in. diameter, 3 in. deep, with a flanged edge. It is packed with slag wool and bolted concentrically to the front face of the door on top of the asbestos sheets. This construction avoids metallic contacts other than the shanks of the bolts, between the inner part of the lid and the outer cover.

The reason for finishing the electrical winding three inches from the front of the inner shell will now be obvious. The first three inches of oven space are filled by the insulating portion of the lid.

The appearance of the oven is greatly improved by a coating of hard-drying black enamel.

During the initial heating process the switch is turned to the position marked "high." The two halves of the winding are then running in parallel so that the power consumed is 8 ampères at 220 volts, i.e., 1760 watts. The time required for the empty oven to reach a temperature of 170° C. in these circumstances is 30 minutes.

When the running temperature of 170° C. has been attained the switch is turned to the position marked "low." In this position the temperature of the oven remains constant or rises very slowly, the variation depending upon the room temperature. In any case turning off the current for a few minutes, say when the temperature reaches 180° C. (which occurs only two or three times during the sterilising process) causes such little trouble that the provision of a thermoregulator is hardly warranted.

SOIL SALINITY IN WESTERN AUSTRALIA.

Preliminary Investigations Into the Movement of Salt in the Red Brown Earth Zone Under a 15 to 25 inch Annual Rainfall.

L. J. H. TEAKLE.

The problem of soil salinity in the wetter portions of the agricultural areas of Western Australia has been apparent during the last 40 years. Manifestations are particularly noticeable in the Great Southern Districts but extend north to the Geraldton district and are even observed in the high rainfall coastal areas. Perhaps the most obvious occurrences are in the 15 to 25 inch rainfall belt or red brown earth zone, although in the light rainfall areas saline soils occur and may affect crop yields. The movement of soluble salts in soils in the light rainfall areas has already been discussed by Teakle and Burvill (1938) and will not be examined further here. In this paper the discussion is confined to the 15 to 25 inch rainfall belt.

Everybody acquainted with these areas is familiar with the glistening, crusty, bare patches and flats along many creeks and valleys. Also, salinity of dams and wells has further focussed attention on the problem not only from the agricultural point of view but also from the point of view of railway engineers.

Farmers early explained the "rise" of salt as due to the wholesale destruction of timber along the creeks and many advise leaving strips to "keep down" the salt. The fallacy of this diagnosis was rendered obvious by the death of timber left along many creeks for this purpose and a number of early writers pointed to a more sound explanation of the phenomenon. O'Brien (1917) writing in 1912 stated that, following clearing "natural vegetation no longer utilises the larger proportion of the rainfall, which entering the ground dissolves more or less of the salts, and as it soaks through the soil and gradually flows down the hillside to the lower land, the water carries the salts with it. In the summer time heavy evaporation takes place from these lower lands, the salt being left behind. After a few years this naturally results in large increases of salt in the hollows, and they are known as salt pans, samphire flats, or salt lakes." Paterson (1917) reported evidence purporting to substantiate this explanation and expressed the opinion that "after clearing, the whole tendency of salt is to leave the higher ground." Wood (1924) has presented further evidence and discussion supporting this explanation. He points out that generally the salinity of ground waters increases with depth and the removal of timber so increases percolation that the lower and more saline waters are driven into the valleys and lead to the development of soil salinity. Analyses reported show that within a few years of clearing catchment areas waters entering dams increase materially in salinity. For instance, at Cranbrook, waters which originally carried about 7 grains of salt * per gallon † increased following cultivation of the catchment areas to 73 grains per gallon. Likewise, "rivers" and intermittent streams have increased in salinity following agricultural development of the drainage areas. Thus, the Blackwood River water at Bridgetown apparently contained about 11 grains per gallon of salt in 1904. Between 1910 and 1917 in the course of 24 periodic examinations it has only once dropped below 20 gr. per gallon and three times has equalled or exceeded 100 gr. per gallon. The Murray River which drains a similar belt of country to the north (Hotham Valley) has

* Throughout this paper "salt" is reported as NaCl calculated from chlorides in solution.

† One grain per gallon is equivalent to 14.3 parts per million.

shown a similar increase of salinity. This river is particularly saline after the first winter rains which flush out the accumulations of the preceding summer. The maximum salinity reached in 1937 was 141 grains of salt per gallon at the sampling on May 25th and, in 1938, 170 grains of salt per gallon on August 1st. During the summer months the salinity appears to range between 20 and 50 grains per gallon. (Figures by courtesy of the Hydraulic Engineer, Public Works Department.)

Wood (1924) concluded that this salt is of "cyclic" origin, that is, is blown in from the sea and deposited on the ground as a dust or in the rainfall. Teakle (1937) has supported this with data from various sources.

General features of the red brown earth zone.

The 15 to 25 inch or red brown earth zone of Western Australia is typically of hilly topography and is drained by numerous creeks. The soils generally are sandy to loamy in texture at the surface with a clayey subsoil. At varying depths—from a few inches to many feet—decomposing rock occurs and it is in the deeper, clayey layers that the "cyclic" salt accumulates under virgin conditions. The rainfall is of winter incidence and 10 to 20 inches will generally fall in the months May to October. This concentration of precipitation promotes leaching and the normal soils are typically of the moderately leached type in which calcium carbonate has been removed or washed to the deeper layers of the subsoil.

Rainfall records for representative centres are given in Table I.

TABLE I.

Rainfall Records for representative centres of the red brown earth zone.
(C.S.I.R., Aust., Pamphlet 42, 1933.)

Centre.	No. of Years.	Average Rainfall in Points (100 points = 1 inch).												Total
		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	
Chapman	25	27	48	65	44	234	438	399	263	162	96	29	22	1,827
Watheroo	32	41	58	70	71	232	368	326	222	158	87	32	36	1,701
Northam	50	28	38	73	81	220	332	348	255	162	99	39	35	1,710
Katanning	39	37	57	95	118	235	296	308	244	194	156	68	62	1,870
Gnowangerup ..	25*	58	68	113	145	217	230	218	190	162	140	65	63	1,669

* Information from the Divisional Meteorologist, Weather Bureau, Perth, to 1937.

The surface layers are normally low in salt in the virgin state, but some concentration occurs in the deep subsoil (see appendix).

The problem.

In developing a farm, clearing is usually first undertaken on the more productive soil types. These typically occur in the valleys and on lower slopes and cultivation is carried on more or less independently of the minor topographic features. The first manifestation of enhanced water movement is on the surface where development of gutters in the valleys may occur in the course of two or three years or more. Later, moist patches, indicative of subsoil water movement, appear in these valleys and frequently salt accumulates as a surface crust, a residue the result of evaporation of water containing soluble salts. These salt patches may be limited to a few yards in extent or may extend over many acres in extreme cases. Such large patches may be observed along the north branch of the Mortlock River at Goomalling, also at Wagin and many other centres, and are well illustrated in map of Beegenup (Fig. 1). The cross hachure in this instance shows the occurrence

of salt in a strip about 10 chains wide in the valley of the creek. Side extensions are observed along tributary creeks and gutters and in the south-west corner of the map is to be seen a salt patch developing as a result of a saline spring on the slope, well above the level of the valley (see Table 4 for analysis of water sample 125 from site 20 at the upper end of this patch).

The manifestation of the salt problem is most common in the valleys and along creeks but also occurs on the slopes where seepage of water brings the salt to the surface. The first appearance is generally noted within a few years of clearing and salt accumulation reaches a maximum in 10 to 20 years. Thereafter improvement is commonly observed. In the lower rainfall portions of this zone, and where heavy textured soils limit underground water movement, marked appearance of salt patches may be postponed for 15 to 20 years after clearing, the maximum is reached much later and recovery will be much slower.

In such areas, dams in lowlying parts frequently become saline due to saline ground water entering the bottom as the water table rises, to saline streams entering the dam and also to the flushing of saline patches in the catchment area. The salt dam shown in the south-east part of the map (Fig. 1) was regularly used for stock purposes 40 years ago but became brackish about 1910. The water showed 5,700 grains of salt per gallon and 6,200 grains total water soluble salts per gallon in February, 1938. (Water sample 132, Table 4.) Likewise wells have become saline as on Mr. A. M. Stewart's farm, Wagin. The water from this well contained 1,690 grains of salt per gallon on 17th April, 1936.

In dealing with this soil salinity problem four questions may be asked:—

1. What is the course of manifestation under different circumstances?
2. What are the limits of extension?
3. What management methods should be adopted?
4. Will the situation improve or deteriorate?

Water Movements.

In order to understand the problem, it is first necessary to understand water movement in soils under the conditions prevailing.

While a certain amount of the soil water may arise from cooling magmas, that of importance has its origin in the rainfall and is known as meteoric or precipitation water. Only meteoric water will be considered.

The rainwater falling on the soil is lost in various ways.

1. Some runs off the surface.
2. The rest percolates into the soil and—
 - (a) later evaporates from the surface,
 - (b) is lost by the transpiration of the plants growing on the soil,
 - (c) remains in the deeper subsoil or joins the ground water and escapes in the underground drainage system of the area.

Under virgin conditions in the red brown earth zone (15 to 25 inch rainfall) run-off is small and creeks flow for only short periods, percolation to the ground water is probably not of major importance but is sufficient to produce the characteristics of a moderately leached soil. Transpiration is undoubtedly the major avenue for water loss.

As the vegetation is selective in the absorption of salts from the soil most of the "cyclic" salt from the rainfall remains in the soil and is gradually leached to lower levels and accumulates in the lower ground waters. A balance will be established so that the outgo of salt will equal that coming in and, consequently, the salt concentration in the subsoil and the salinity of the ground water will be dependent on the proportion of water percolating and escaping in the underground

drainage. It would be expected that heavier soil types, which restrict water movement and favour loss by evaporation and transpiration, would contain a higher percentage of salt and associated ground waters would be more saline than where porous soils exist. The higher salinity of the heavier soils has been proved in the course of extensive soil surveys in 12 to 15 inch areas and farmers of the red brown earth zone have frequently observed brackish springs to be associated with the heavy soils formed from basic dykes.

When the land is cleared, or the timber otherwise destroyed, surface run-off is accelerated and is evidenced by soil erosion. Also percolation is greatly enhanced and much more water reaches the ground water annually. Small underground streams make their way toward the valleys and the water table rises generally but more particularly in the valleys. Within a few years permanent water commonly occurs in the major creeks and many small tributaries as a result of this enhanced underground water movement. Springs break out on slopes, seepage patches appear, the water rises in wells, and sometimes water invades the bottoms of dams.

Mr. A. Hardie of Narrogin and Mr. A. A. Toll of Highbury have observed that the greatest flow of such springs, apart from the temporary winter flush, on their properties is during February, March and April. It apparently takes several months for the seasonal underground flow to reach the springs. The intake beds for this water must therefore be some distance away, probably many chains, and local water, that is water falling in the immediate vicinity, is of scant importance in promoting the formation of seepage patches.

The Salt Problem.

In the course of discussing the movement of water in the soils of the red brown earth zone the accumulation of salt in the subsoil and ground waters resulting from the selective absorption by vegetation has been mentioned. It was explained that the concentration of salt will depend primarily on the ratio of outflow to total percolation and this is determined largely by the porosity of the soil and the nature of the vegetation. Heavy soils, in which percolation is restricted and which usually carry a heavy growth of timber, will essentially be higher in salt than light and porous soils but the difference will be quantitative and the accumulation will involve identical principles.

With enhanced water movement following clearing or destruction of the timber the equilibrium is upset and salt begins to move out of the soil with the water. Equilibrium under cultivation will involve a much lower salt concentration in the soil.

The underground drainage conditions are inadequate to remove the extra water and water tables rise. This is noticed particularly in the valleys where creeks may develop permanent pools and the ground water may affect dams. Unfortunately, this new flow of water is frequently brackish or somewhat saline due to the accelerated removal of the salt which has accumulated in the soil over the ages. And the salt concentration will be determined by such factors as the nature of the soil, the amount of percolating water, etc. Also, the rising ground water may be brackish or saline.

When this brackish or saline water comes within 3 or 4 feet of the surface, capillarity may be active enough to maintain surface evaporation of water and this leads to the surface accumulation of salts and consequent soil salinity, which may extend over considerable areas of erstwhile fertile soil.

Similarly, by evaporation, pools and dams affected by the rising water table may become exceedingly saline as the season advances. (See samples 132 and 137, Table 4.)

The Course of Manifestation.

The general course of manifestation of soil salinity in the red brown earth zone has been discussed above. Unfortunately, details are sadly lacking and organised enquiries are necessary to obtain information of considerable importance from the point of view of crop production and farm water supplies.

A few cases may be cited to indicate the type of evidence so far obtained. These probably represent conditions throughout the zone with some accuracy.

1. Mr. MURDOCK, BALLAYING.

(Examined April 16th, 1936; Loes. 2021, 4138.)

A salty valley 15 to 20 chains wide runs through the property and spread is apparently being retarded by a shallow drain cut through the lowest part. Before clearing 20 years previously the water table stood at 12 to 13 feet. Water under some pressure was encountered at 3 feet 6 inches on April 16th, 1936, and was found to contain 2,430 grains of salt per gallon. The total water soluble salt content was 2,650 grains per gallon.

2. Mr. A. M. STEWART, "Solai," WAGIN.

(Examined April 17th, 1936.)

A flat, which had originally carried york gum and jam timber and from which the land rises fairly abruptly, was cleared in 1911 and 3 good crops of cereal hay obtained. Evidences of salt appeared within 5 or 6 years and spread rapidly. Now some 200 acres of 500 are too badly affected to warrant cultivation and the remaining 300 acres are more or less affected.

A well on the edge of the flat near the stables is now salty and the water level was within 3 feet of the surface. The water contained 1,690 grains of salt per gallon. A number of mound springs were also observed on the flat. Water from one such spring contained 1,080 grains of salt per gallon and 1,280 grains of total water soluble salts per gallon.

3. Mr. AUSTIN PIESSE, WAGIN.

(Examined April 17th, 1936.)

A salt affected creek and small salt flats were observed, but the problem appeared of small magnitude. A spring in the bank of the creek yielded water containing 784 grains of salt and 987 grains of total water soluble salts per gallon.

4. Mr. S. C. DALL, QUAIRADING.

(Information supplied November 17th, 1938.)

At time of clearing in 1907 the salt water stood at 21 feet below the surface in salmon gum and gimlet flats. It is now within 14 feet of the surface. The rise is attributed partly to drainage from the north-east along the salt channel through Hines Hill, Nungarin, Lake Brown, etc.

5. Mr. C. TAYLOR, "Beegenup," BROOME HILL.

(Examined February, 1938.)

A more exhaustive examination was made of Mr. Taylor's property to obtain reliable data concerning the manifestation of the problem. Unfortunately, Mr. Taylor had been in possession of the property only since September, 1928, and early history was not readily available. He estimated that about 90 acres were

salt affected in 1929 and some 150 acres in 1937. This alarming spread led him to seek advice with the result that an investigation was undertaken.

A general soil survey of the property was made to determine the nature of the soils and the incidence of salt carefully examined. Figure 1 represents the results

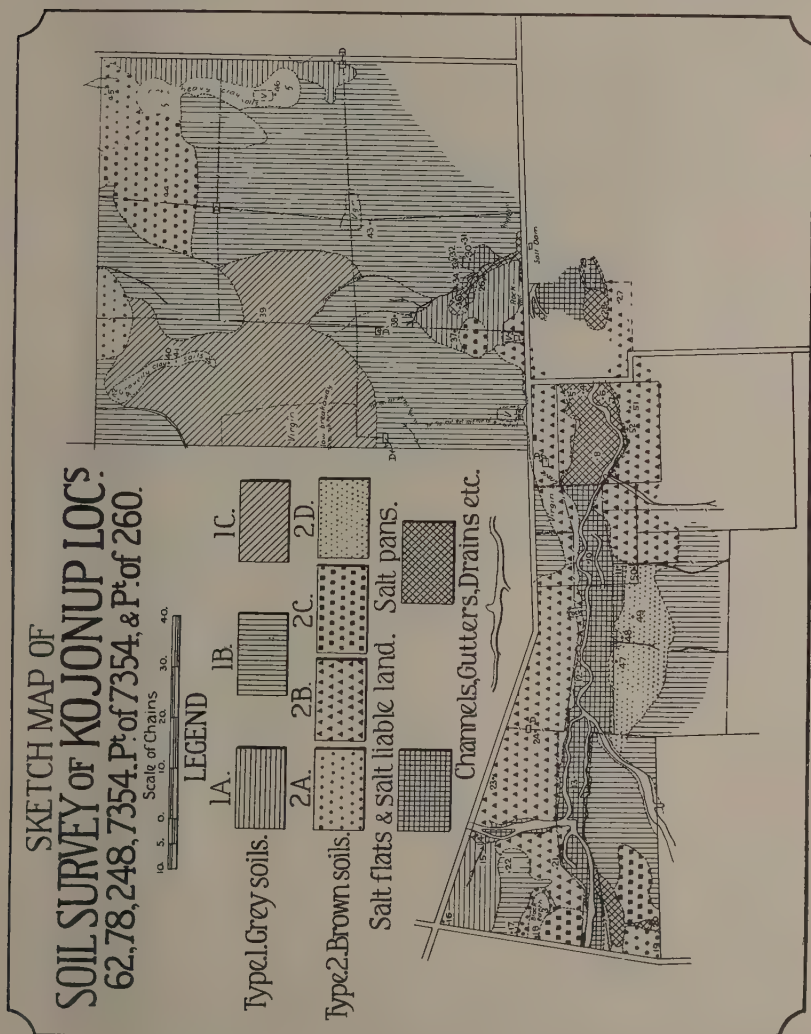


Fig. 1.—Sketch map of Beegenup Soil Survey.

of the soil survey and shows the occurrence of salt along the creek and tributaries, gutters, etc. through the property. The soil types are described in the Appendix, but pertinent details of the factors relating to the incidence of salt are recorded below. The location of sites sampled are shown by the numbers on the plan. (Figure 1).

The property is situated in hilly country and is drained by the Beegenup Creek and its tributaries. The creek valley averages about 10 chains wide and is generally uncleared except in the eastern 20 chains. It has been fenced off, partly on account of the salt incidence, and farming operations, involving the production of wheat and the raising of sheep, are confined to the slopes and higher land.

The slopes rising from the valley of the creek are quite marked and would generally be 3 to 5%. Steeper slopes occur in parts.

The chief timbers of the property were york gum (*Eucalyptus foecunda* var. *loxophleba*), morrel or poot (*E. longicornis*), wandoo (*E. redunca* var. *elata*), yate (*E. cornuta* or *occidentalis*), and jam (*Acacia acuminata*). Wandoo grows most typically on the more gritty, gravelly and sandy grey soils and yate in the wetter areas. York gum is more typical of the heavier textured brown soils of the valley. Morrel, york gum, wandoo and jam may form an association which is uncommon in more northern districts. Needlebush (*Hakea Preissii*) grows on the heaviest soils such as black earth and in the creeks. Mallees (*Eucalyptus annulata* and spp.) grow on patches of heavy, tenaceous clay soils.

The soils are representative of the red brown earth zone in many characteristics. (See appendix). In addition to the valley bottom soils two main groups occur: (a) the brown and brownish soils, generally on the lower slopes of the valleys (Types 2A, 2B, 2C and 2D) and (b) grey soils with more or less pipe clay in the subsoil and frequently showing admixture of ferruginous gravel (laterite). (Types 1A, 1B and 1C.) The brown soils appear to be forming on granitic rocks exposed by erosion and the grey soils on a much decomposed white rock horizon containing much quartz and kaolin and sometimes rounded pebbles.

Analyses of representative samples of these soils are summarised in the distribution table—Table 2. Details are given in the Appendix.

TABLE 2.

Distribution Table showing the Range of Salt Concentration in Profiles (a) from Normal Soils of Types 1 and 2, (b) from the Valley and Seepage Areas where Salt appears on the surface.

Range of Salt Concentration : per cent. NaCl.	Number of Samples in each Range.									No. of Sites.
	Above 1.00.	0.75-1.00.	0.50-0.75.	0.25-0.50.	0.15-0.25.	0.10-0.15.	0.05-0.10.	0.01-0.05.	Below 0.01.	
(a) Normal Soils of Types 1 and 2—Cleared and Cultivated country.										
0-12in. deep							3	12	6	21
12-24in. deep					1	1	7	8	4	21
24-48in. deep				1	1	4	8	4	1	19
Below 48in. deep					2	1	....	....	....	3
(b) Valley Soils, etc., where Salt appears on the surface.										
0-12in. deep			5	2	3	3	2	....	....	15
12-24in. deep		1	1	3	1	6	1	1	....	14
24-48in. deep			2	5	3	1	1	1	....	13
Below 48in. deep			2	7	1	1	....	....	....	11
Concentration of Salt in surface ¼ in. to 1 in. layer of valley types, etc., where Salt appears on the surface										
7.52%, 4.86%, 6.83%, 4.2%, 1.96%, 5.75%, 0.77%, 0.64in.%, 1.11%, 1.76%, 8.29%.										

This information may be presented in the form of weighted averages for the various horizons. These averages may serve to emphasise the contrast between normal soils and the valley soils where salt is now apparent.

The comparison is as follows:—

Layer.	Normal country types 1 and 2.	Valley soils and soils from seepage patches where salt accumulation is apparent.
	per cent. salt*.	per cent. salt*.
0-12 inches	0.024	0.36
12-24 inches	0.052	0.26
24-48 inches	0.09	0.33
Below 48 inches	0.18	0.37

* Salt calculated as sodium chloride from chloride and expressed as per cent. in the oven dry soil.

The normal soils are quite low in salt but some concentration (0.18 per cent. salt) occurs in the deep strata (below 48 inches). It is most likely that some leaching has occurred as this land was cleared many years ago.

If it be assumed that the salt concentration of the normal soils of types 1 and 2 was originally similar to that of the valley soils before the rise of the water table, it is obvious that considerable accumulation has resulted from the movement of saline water. The most marked accumulation, of course, is in the upper layers, affected by surface evaporation of water. As shown in Table 2 the surface half to one inch layer may contain several per cent. salt and the above averages depict the considerable accumulation which has occurred in the layers to a depth of 48 inches. The usual salt concentration gradient of a soil profile, which is represented by the results quoted for normal soils, has been upset. Below 48 inches these valley soils are more saline than the normal soils but the difference is much smaller. Whether this is the result of water movement since clearing the country took place cannot be determined but it seems probable that the present difference is due at least partly to recent contact with saline water.

These observations lead to a consideration of the composition of the subsoil and percolating waters to which the development of this manifestation of soil salinity is ascribed. Some 29 samples on "Beegenup" and neighbouring farms were collected and analysed.

All waters examined were slightly alkaline in keeping with the reactions of the subsoils.

TABLE 3.

Distribution Table showing the Range of pH Values of Waters collected in the course of the Beegenup Survey.

Range pH ...	Number of samples in each range.							No. of Samples.
	7.2-7.4.	7.4-7.6.	7.6-7.8.	7.8-8.0.	8.0-8.2.	8.2-8.4.	8.4-8.5.	
	2	3	6	4	3	12	2	32

The salinity (salt and total water soluble salts) is shown in Table 4 together with information concerning the salt content of the subsoil below the level of the water table.

TABLE 4.
Composition of Waters and Soils in Contact with this Water on Beegenup and neighbouring Farms.

Serial No.	T.W.S.S. gr./gal.	Salt (NaCl).		Salt Content of Soil in Contact with water. per cent.	Ratio— Salt in Soil 100 × Salt in water	Average Texture Classes of Soil Horizons in Con- tact with Subsoil Water.	Depth of Water below Surface after standing 24 hours.
		gr./gal.	per cent.				
(a) Along Mullidup Creek on Mrs. Stewart's Property, about 1 mile N.W. of Beegenup—							
106	70	52	·075	N. D.	...	...	60
107	230	175	·25	N. D.	...	...	Well 24ft. deep.
108	525	475	·68	N. D.	...	...	Well 13ft. deep.
109	119	98	·14	N. D.	...	...	Well 12ft. deep.
111	720	660	·94	N. D.	...	...	Well 15ft. deep.
110	2,200	1,990	2·84	N. D.	...	...	Spring in bank of creek.
							Water in creek sands adjacent to spring.
(b) Samples along Beegenup Creek and Mullidup Creek—							
113	1,410	1,270	1·81	N. D.	...	...	Site 5 in salt pan.
114	1,440	1,270	1·81	N. D.	...	...	Site 4 in salt pan.
115	1,390	1,200	1·72	N. D.	...	...	Site 6 in salt pan.
116	1,390	1,260	1·80	N. D.	...	...	Site 7 in salt pan.
117	1,480	1,380	1·97	0·39	19·8	Sandy loam ...	Site 8 in salt pan.
118	1,560	1,420	2·03	0·36	17·7	Sandy loam ...	Site 9 in york gum flat.
119	1,530	1,380	1·97	0·41	20·8	Sandy loam ...	Site 10 in york gum flat.
122	2,230	2,040	2·92	...	...	Clay ...	Site 13 in york gum flat.
126	1,600	1,500	2·14	0·44*	20·6	...	Site 25 in cleared area
123	2,390	2,250	3·32	0·54*	16·8	Sandy loam ...	Site 14 in salt flat along Mnl- lidup Creek
(c) Samples from Salty Patches on Slopes above the Creeks—							
120	1,410	1,250	1·78	0·26	14·6	Sandy loam ...	Site 11, top end of salt patch.
121	1,180	1,060	1·52	0·30	19·7	Sandy clay ...	Site 12, top end of salt patch.
125	1,620	1,520	2·17	0·45	20·7	Clay ...	Site 20, top end of salt patch.
127	1,510	1,410	2·02	0·46	22·8	Clay ...	Site 26, in salty tributary.
128	1,620	1,490	2·13	0·34	16·0	Sandy laom ...	Site 28, salt patch.

130	1,250	1,170	1.67	0.26*	15.6	Pipe clay	...	41	Site 30, salt patch.
131	1,230	1,140	1.63	0.21	12.9	Pipe clay	...	36	Site 36, top end of salt patch.
134	930	900	1.28	0.14	10.9	Clay	...	49	Site 48, top end of salt patch.
136	1,150	1,060	1.52	...	...	...	...	12in. above creek level	Site 52, salt spring flowing into creek.
<i>(d) Samples from Slopes where no evidence of Salt appears—</i>									
124	625	555	.79	0.18*	22.8	Pipe clay	...	71	Site 15.
129	560	460	.66	0.08	12.1	Sandy loam	...	69	Site 29.
133	1,250	1,130	1.61	0.21	13.0	Loamy sand	...	56	Site 47, good stubble.
135	840	780	1.12	0.18*	16.1	Pipe Clay	...	65	Site 50, grassy slope.
<i>(e) Dams and Pools—</i>									
112	35	35	.05	...	...	...	...	...	Nigalup dam unaffected by salt influences.
132	6,200	5,700	8.12	...	...	...	...	...	Salt dam opposite site 25; affected by rise of salt water table.
137	5,100	4,700	6.68	...	...	...	...	...	From pool in creek near site 52.

* Includes material above and below the water table.

The low ratio of salt in the soil to salt in the water is suggestive that the soil and the invading waters are not yet in equilibrium and that the salt water exists largely in channels and cavities in the soil mass. It has not yet displaced entirely or thoroughly mixed with the fresh capillary water originally present in the soil.

This deduction gives rise to a problem of considerable importance and which requires early investigation. The information given in Table 4 indicates that the salinity of the ground water along Beegenup and Mullidup creeks resembles that of streams encountered at salty patches on the slopes in the vicinity. It may be asked whether the ground water encountered in the creeks is merely a continuation of the streams seeping in from the slopes or represents the water table risen from a considerable depth during the period since clearing was commenced?

Waters of similar salinity have been encountered in many other parts of the zone and representative analyses are given in Table 5.

TABLE 5.

Salt Content of Subsoil Waters and Spring Waters in the Red Brown Earth Zone.

Serial.	District.	Source.	Depth of Water.	Salt content.	
				Per cent.	Grains per gallon.
			feet.		
1	Moulyinning	Subsoil	5	3.22	2,250
2	do.	do.	3	2.83	1,980
3	do.	do.	2½	1.09	763
4	do.	Sand soak	?	0.34	238
25	Wagin	Mound spring	...	1.55	1,080
29	do.	Well	3	2.42	1,690
30	Ballaying	Subsoil	3½	3.47	2,430

Summarising the discussion leading up to the answer to the first question proposed on page 436 it is stated that there can be little doubt that the development of soil salinity in the red brown earth zone is generally due to the accelerated movement, following clearing of the timber, of brackish and saline waters. This leads to the formation of a shallow water table in valleys and to seepage patches on slopes. When the water level is within 3 or 4 feet of the surface, a continual supply of moisture to the surface may be maintained. Evaporation of this moisture occurs, particularly in the summer months, and results in surface accumulation of soluble salts—and the manifestation of soil salinity.

Limits of Extension.

It has been shown that the development of soil salinity in the red brown earth zone is generally the result of water movement. Brackish or saline water seeps to lower levels and may raise the ground water to such an extent that capillary forces may bring salt to the surface. At the same time many creeks flow over much longer periods than before clearing took place and may contain more or less permanent pools of water. If the incoming water raises the water table above the level served by the bottom of the creek the excess water will be rapidly removed by a flow in the channel. Thus the level of the channel controls the height of the water table in the valley and limits the extension of the salt affected areas. It is improbable that soil salinity will develop in this zone if the water table is lower than 6 feet from the surface. There are no grounds for the fear that the salt will creep up the slopes and ruin large areas of good land.

The evidence of soil salinity on the slopes arises from saline underground streams reaching the surface, as a result of clay bars, rocks, etc., before they reach the valleys. The saline patches resulting cannot be expected to extend to large dimensions and are regarded as inconveniences rather than serious liabilities.

The answer to the second question proposed on page 436 is that, although salt encroachment is rapid for a period, extension is limited to valleys where a brackish or saline water table may reach within a few feet of the surface and to the vicinity of seepage patches forming on slopes. The problem may affect some farmers severely but does not jeopardise agriculture.

Management Methods.

Many people appear to believe that the salt in some way rises out of the valleys and encroaches on the higher land. In consequence, the leaving of green timber along creeks and valleys is advocated to "keep down the salt." From the foregoing discussion it is obvious that the salt does not owe its origin to the conditions in the valleys but to the seepage of waters from the higher country following the clearing of the area. If the higher country be cleared and can act as an intake bed for moisture, no amount of timber in the valleys can prevent the extra water from seeping in. The green timber may absorb a considerable proportion of this water and so retard the development of a shallow water table. In many cases, as at Beegenup, the saline ground water rises and the valley soils become saline both in the timbered and cleared areas. Furthermore, there are many instances of the timber dying as a result of the risen water table and soil salinity.

Therefore, as far as the development of soil salinity is concerned, the leaving of timbers in the valleys will be a minor factor in control measures and such manifestations must be accepted as a consequence of the development of the country.

From other points of view, such as the aesthetic value, the provision of shelter belts for stock, provision of some measure of control of wind erosion and economy in clearing costs, it is highly desirable to leave belts of timber along valleys and is strongly recommended.

Where saline patches occur in cultivated land, cultivation of the salty areas is desirable to promote water absorption and leaching, to limit surface evaporation and wind action and to facilitate the establishment of a vegetation cover of some agricultural value. Mr. S. C. Dall, of Quairading, finds that bare fallowing favours the extension of the saline bare patches, but autumn plowing coupled with wet seeding, after the first rains have washed the surface salt into the subsoil, brings about an appreciable establishment of crop on areas otherwise sterile.

There seems little evidence of deleterious effects from cultivating saline patches. The weight of evidence in answer to the third question proposed on page 436 favours cultivation to promote the washing down of the salt and to afford a better chance of crop establishment. Conservation of moisture over the summer period by bare fallow is undesirable. The objective is the establishment of a vegetation cover and special crops may be sown, fertiliser applied and farm management adapted to promote this end.

Future Development of Soil Salinity.

An understanding of the fundamental factors underlying the soil salinity problem in the red brown earth zone leads to an optimistic view of the future. There can be no doubt that accelerated drainage accompanies the rise of water tables and development of seepage patches and springs which result from enhanced water movement following clearing of the surrounding country. The incoming water is relatively pure, as rain water will average 1 to 2 grains of salt per gallon, and this water will gradually displace the more saline subsoil water. The first

results of the displacement process as shown by Burd and Martin (1923) will be the appearance of the saline subsoil water in the valleys and at seepage patches or springs. As displacement proceeds more or less imperfectly due to cracks and channels in the soil, dilution of the saline water will occur and the percolating water will become less and less saline. Eventually the whole of the saline water will be removed and subsoil waters, where drainage is possible, will become fresh or non-saline. This conclusion is of great importance to many agriculturists. Tangible evidence that this is happening is available and a few instances may be cited as representative:

Mr. Ashworth, of Yilliminning, has reported that two wells on his property which were saline 12 years ago are now fresh. A similar decrease in salinity has been observed in a well on the Chapman Research Station.

Mr. Cliff Anderson, of "Narrawong," 14 miles west of Katanning, in discussing the conditions on his property, stated that, after clearing the surrounding country in 1907, salinity developed in the water of a valley through the property to such an extent that it became unfit for stock. The salinity appeared to increase until 1930, but thereafter improvement commenced and by 1937 the water of the valley was quite "sweet" and suitable for stock purposes.

Mr. E. H. B. Lefroy, of Walebing, and Mr. Austin Piesse, of Wagin, report that saline patches are beginning to grass over after being bare for 10 to 20 years. Similar observations have been made by the writer in the Northampton district.

Generally in the better rainfall areas, and where very heavy textured soils are not very prevalent in the lower rainfall portions of the zone, such improvement is noticed within 10 to 20 years of the appearance of the trouble. Where the heavier textured soils occur under a 15 to 17 inch rainfall the movement of water, and hence salt, is slower. The evidence of salinity takes longer to appear and it is certain that a good many years may elapse before improvement sets in. No estimate of this time factor can be made at present.

Certain action may be taken to assist nature in the removal of salt occurring under these circumstances. Flow in the creeks should be facilitated to accelerate drainage. Seepage patches occurring on slopes may be tapped by T drains. The top part of the T drain intercepts the percolating water and the stem removes it to the valley. Moisture absorbing plants of some salt tolerance may be established to utilise portion of the percolating water and provide feed for stock. Judicious cultivation and cropping will promote reclamation.

The answer to the fourth question proposed on page 436 is that salinity of soils and waters may increase rapidly for a period and will reach a peak. Continued displacement by the percolating rainwater will then bring about improvement and in the course of time the soils and underground waters will lose their salinity and become of agricultural value.

Summary and Conclusions.

Evidence has been presented to show that soil salinity develops in the red brown earth zone of Western Australia, under a 15 to 25 inches rainfall, largely as a result of enhanced movement of water following the clearing of the country. The "cyclic" salt which accumulated in the deeper layers of the subsoil and in the decomposing rock below under virgin conditions, is washed downwards with the increased water percolation following clearing. With the water, it reaches the valleys or springs and seepage patches, and surface accumulation of the salt occurs when the ground water is within a few feet of the surface. Analyses show that concentrations of waters in the vicinity of saline areas commonly range from 1,000 to 2,000 grains of salt per gallon and where surface evaporation of water occurs the surface inch of soil may contain several per cent. salt.

As the incoming rain water is relatively pure, containing only 1 to 2 grains of salt per gallon, continued displacement, if imperfect, leads to the removal of the salt and eventually the percolating water will become fresh. This fact is of great importance with respect to supplies of stock water and water for agricultural purposes. Concurrently, enhanced drainage will remove the salt from the soil and grasses will take possession of the erstwhile saline patches.

Where high rainfall and porous soils facilitate water movement through the soils improvement is noticed in 10 to 20 years but many years may elapse before evidence of reclamation is observed where heavy textured soils predominate and the rainfall is less generous.

Nature may be assisted in the reclamation of saline areas in this zone by facilitating drainage, establishment of a vegetation cover by appropriate cultivation and other means.

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APPENDIX.

Details of soil types recognised and mapped in the Beegenup soil survey—See Fig. 1.

The soils fall in Avon region of the red brown earth zone and exhibit the main features of soils of that zone—clay accumulation in the subsoil, alkaline reaction in the subsoil and occasional occurrence of calcium carbonate in the deeper subsoil. The colour factor is variable as the range is from red brown to light grey. The brown soil types generally form on material from rocks of the granitic or gneissic type and the grey soils from a kaolinised horizon, apparently a metamorphosed sediment which has not been identified geologically. An interesting occurrence of black earth was discovered on a basic dyke. Laterite capping and laterite gravel are common, particularly on the higher levels and are associated with certain of the grey soil types. Small areas of other soil types were recognised. With the exception of certain valley soils all samples were from cleared and cultivated areas.

A. Grey soil types.

—associated with kaolinised rocks.

3 types of grey soils were recognised and mapped.

TYPE 1A.

0 to 9 or 12ins.: grey loamy sand to sandy loam more or less gritty.

9 or 12ins. to 4ft.: yellowish to greyish gritty clay—more or less soapy feel.

Below about 4ft.: pipe clay.

Timbers: wandoo, morrel, york gum.

TABLE A.

Salt Content and Reaction of Soils of Type 1A.

Site.	Depth.	Salt (NaCl). %	pH.	Site.	Depth.	Salt (NaCl). %	pH.
15	ins.			16	ins.		
	0-10	·05	7·14		0-9	·01	6·52
	10-26	·07	8·44		9-24	·05	8·96
	26-32	·07	8·56		24-36	·11	8·86
	32-50	·06	8·30		36-	·14	7·42
	54-79	·18	8·45	37	0-10	·01	6·49
					10-24	·02	7·47
					24-40	·03	8·08

TYPE 1B.

0 to 4 or 6ins.: light grey gritty loamy sand to sandy loam.

4 or 6ins. to 2ft.: light brownish grey with orange mottlings gritty sandy clay loam.

Below about 2ft.: white and yellowish pipe clay.

Timber: wandoo.

This type appears to be somewhat acidic in some instances. Influence of laterite may in some measure account for this and therefore these sites show an affinity for type 1C.

TABLE B.

Salt Content and Reaction of Soils of Type 1B.

Site.	Depth.	Salt (NaCl). %	pH.	Site.	Depth.	Salt (NaCl). %	pH.
17	ins.	%		31	ins.	%	
	0-4	·02	6·78		0-15	Trace	6·54
	4-28	·03	8·26		15-27	·01	6·90
	28-38	·09	8·13	38	0-8	·02	6·96
22	0-3	·03	6·62		8-20	·03	8·04
	3-20	·04	8·22		20-36	·06	8·22
	20-	·13	8·14		36-45	·06	7·98
34	0-12	·05	6·47	43	0-5	·01	4·97
	12-21	·16	6·14		5-17	·02	5·51
	21-41	·34	5·12		17-32	·03	5·38
					32-40	·06	6·15

TYPE 1C.

0 to 18in.: dark grey to yellow brownish grey sand with quartz, grit and iron-stone gravel.

18 to 25in.: yellowish grey brown very gravelly sand.

25in. to 3ft.: yellow brown and red gravelly cementy sandy clay loam.
pipe clay occurs below this horizon.

The soil is very low in soluble salts and slightly acidic to neutral in reaction.

The lateritic material has probably affected the properties to an important extent.

TABLE C.
Salt Content and Reaction of Soils of Type 1C.

Site.			Depth.	Salt (NaCl).	pH.
39	...	...	ins.	%	
			0-18	Trace	6.61
			18-25	Trace	7.19
			25-36	Trace	6.90

B. Brown soil types.

—associated with granitic or gneissic rocks.

4 types of brown soils were recognised and mapped.

TYPE 2A.

Rich dark brown heavy textured soils somewhat variable in profile.

The profile consists of a rich dark brown gritty loam to sandy clay loam a few inches deep on a red brown sandy clay subsoil which becomes heavier and either more chocolate coloured or yellow with depth. Lime occurs in the subsoil from about 18 inches.

Timber: York gum.

TABLE D.
Salt Content and Reaction of Soils of Type 2A.

Site.			Depth.	Salt (NaCl).	pH.
19	...	...	ins.	%	
			0-5	.02	7.02
			5-16	.04	8.12
			16-24*	.13	8.80
			24-36*	.18	8.85

* Lime present.

Site 20 which had been affected by saline seepage water showed similar reaction values and textures.

TYPE 2B.

0 to 6in.: grey brown gritty loamy sands to sandy loams.

below 6in.: yellow brown to red brown gritty sandy clay with some lime accumulation in the deeper subsoil.

below 3ft.: decomposing granitic or gneissic rock.

TABLE E.
Salt Content and Reaction of Soils of Type 2B.

Site.	Depth.	Salt (NaCl).	pH.	Site.	Depth.	Salt (NaCl).	pH.
21	...	...		45	...	...	
27	...	...		51	...	...	

* Lime present.

TYPE 2C.

Brown to red brown sandy loam about 9in. deep on yellow brown, red brown to brownish red gritty clay with no lime. Decomposing rock at about 2ft.

TABLE F.

Salt Content and Reaction of Soils of Type 2C.

Site.	Depth.	Salt (NaCl).	pH.	Site.	Depth.	Salt (NaCl).	pH.
23	ins. 0-9 9-18 18-24	% ·005 ·007 ·007	6·65 6·82 6·78	44	ins. 0-3 3-14 14-24 24-30	% ·03 ·04 ·06 ·06	6·20 6·70 8·18 8·22
24	0-7 7-16 16-24	·005 ·005 ·005	6·34 6·67 6·92				

TYPE 2D.

0 to 9in.: brownish grey loamy sand to gritty sandy loam.

below 9in.: yellow brown with grey and reddish mottling sandy clay loam to sandy clay. Pipe clay may occur at 5ft.

TABLE G.

Salt Content and Reaction of Soils of Type 2D.

Site.	Depth.	Salt (NaCl).	pH.	Site.	Depth.	Salt (NaCl).	pH.
47	ins. 0-8 8-21 21-24 24-36 36-48 48-72	% Trace ·02 ·03 ·07 ·15 ·21	7·02 7·62 8·14 8·26 8·20 7·80	50	ins. 0-9 9-18 18-24* 24-30* 30-48* 48-55* 55-78	% Trace ·03 ·04 ·04 ·07 ·10 ·18	7·52 8·46 8·78 8·74 8·86 8·74 8·08
Water rose to 56in. and contained 1,130 grains of salt per gallon.				Water rose to 65in. and contained 780 grains of salt per gallon.			
49	0-3 3-11 11-30	·02 ·06 ·08	6·97 8·34 8·68				

* Lime present.

C. Other soil types.

TYPE 3.

Black earth associated with a basic dyke.

Brownish black crumbly clay with a friable clay subsoil and lime accumulation at 2ft.

Decomposing greenstone occurs at 2½ to 3ft. This soil occurs as a strip coinciding with a basic dyke. It cracks badly when dry and, consequently, is difficult to work. In the virgin state it carried needlebush (*Hakea Preissii*).

TABLE H.
Salt Content and Reaction of Soils of Type 3.

Site.	Depth.	Salt (NaCl).	pH.	Description.
18 ...	ins.	%		
	0-9	·02	7·84	brn. blk. crumbly clay.
	9-22	·02	8·52	brn. blk. friable clay.
	22-32*	·07	8·48	brn. blk. calc. clay.

* Lime present.

TYPE 4.

Dark brownish grey clays with ferruginous gravel. These soils occur on the slope of a small ridge which originally carried morrel. They are slightly acidic to alkaline in reaction and showed surface accumulation of salt.

TYPE 5.

Grey tenacious clay, mottled orange and red in the subsoil at 9 to 18ins. The surface is more or less cracked during the dry season and bare patches, showing surface accumulation of salt, are common. An acidic reaction (pH 5 to 6) characterises the type which probably resembles certain soils of the moort (*Eucalyptus platyptus*) country. In the virgin state it carried mallees including *Eucalyptus annulata*; *Wilsonia humilis* commonly grows on the surface of the soil; Barley grass (*Hordeum maritimum*) is characteristic of the cleared areas.

If well cultivated this type grows a good wheat crop in a heavy rainfall season.

D. The Valley Soils.

The valley soils along the Beegenup creek are essentially very variable and show the effect of layering owing to the method of deposition of the material in the past. The textures are generally of the sandy loam class but clay or sandy clay layers may be interposed more or less haphazardly. Surface colours are generally grey to grey brown and chocolate. These colours may extend to the subsoil but orange mottlings and yellow shades are generally noticeable in the lower horizons.

Salt crusts are common: where the valley has been cleared a bare, crusty surface has developed, probably as a result of wind erosion, and is referred to as a salt pan; where the timber, mainly york gum and some flood gum (*Eucalyptus rudis*), remains the surface is generally slightly crusty but friable, the A horizon apparently being still intact. This area is called a salt flat. Rushes and barley grass (*Hordeum maritimum*) also grow on the salt flat.

The analyses of samples from profiles of the valley soils are as follows:—

TABLE I.
Salt Content and Reaction of Soils of the Valley.

Site.	Depth.	Salt (NaCl).	pH.	Site.	Depth.	Salt (NaCl).	pH.
8* ...	ins.	%		9 ...	ins.	%	
	Crust†	7·52	8·05		Crust†	4·86	5·81
	0-17	·74	8·33		0-18	·24	7·07
	17-24	·98	8·06		18-24	·13	7·70
	24-30	1·44	8·10		24-33	·36	7·86
	30-36	·89	7·85		33-36	·51	7·82
	36-57	·30	7·87		36-54	·47	7·92
	57-69	·37	7·74		54-60	·28	7·90
Water rose to 32in. and contained 1,380 grains of salt per gallon.					60-66	·36	8·10
10 ...	Crust†	6·83	6·11	Water rose to 50in. and contained 1,420 grains of salt per gallon.			
	0-12	·62	5·70	14 ...	Crust†	5·75	6·80
	12-24	·15	7·16		0-20	·59	7·58
	24-39	·29	8·20		20-42	·47	8·24
	39-48	·41	7·85		42-	·62	8·21
	48-	·41	8·34				
Water rose to 53ins. and contained 1,380 grains of salt per gallon.				Water rose to 36ins. and contained 2,250 grains of salt per gallon.			

* Salt pan.

† 0 to $\frac{1}{2}$ in. deep.

E. Saline Soils of Seepage Patches.

The profile characteristics of the saline soils of the seepage patches resemble those of the adjacent normal soils except in salt content. Analyses of a number of soils from sites rendered saline by seepage of brackish water are given in Table J.

TABLE J.

Salt Content and Reaction of Soils rendered Saline by Seeping Waters.

Site.	Depth.	Salt (NaCl).	pH.	Site.	Depth.	Salt (NaCl).	pH.
11	ins. Crust*	% 4.20	7.01	28	ins. 0-3	% 1.02	6.92
	0-13	.18	7.95		3-12	.35	8.32
	13-19	.12	7.90		12-23	.28	8.62
	19-30	.15	8.42		23-33	.31	8.68
	30-45	.18	8.25		33-63	.34	8.66
	45-63	.30	8.16	Water rose to 34ins. and contained			1,490
	63-	.36	7.98	grains of salt per gallon.			
Water rose to 36ins. and contained			1,250				
grains of salt per gallon.							
12	Crust*	1.96	6.55	30	0-1	.56	6.59
	0-15	.12	7.47		1-17	.08	6.42
	15-30	.16	8.27		17-30	.11	8.05
	30-38	.26	8.08		30-78	.26	7.65
	38-46	.28	8.10	Water rose to 41ins. and contained			1,170
	46-54	.30	8.16	grains of salt per gallon.			
	54-	.33	7.87				
Water rose to 44ins. and contained			1,060				
grains of salt per gallon.							
20	Crust*	8.29	7.03	32	0-1	.77	5.54
	0-6	1.06	7.90		1-12	.07	5.84
	6-18	.26	8.55		12-23	.01	5.95
	18-44	.34	8.66		23-45	.03	7.26
	44-65	.58	8.38				
Water rose to 18ins. and contained			1,520	33	0-1	.64	5.66
grains of salt per gallon.					1-6	.03	5.99
25	0-10	.34	8.08	35	0-1	1.11	6.67
	10-22	.29	8.28		1-11	.14	6.22
	22-40	.31	8.40		11-18	.11	6.44
	51-55	.70	7.46				
Water rose to 32ins. and contained			1,500	48	Crust*	1.76	7.48
grains of salt per gallon.					0-13	.15	8.24
					13-22	.11	8.36
26	0-8	.81	8.10		22-46	.09	8.72
	8-22	.45	8.16		46-62	.14	8.46
	22-36	.46	8.53	Water rose to 49ins. and contained			900
Water rose to 18ins. and contained			1,410	grains of salt per gallon.			
grains of salt per gallon.							

* 0 to $\frac{1}{2}$ in. deep.

EXPERIMENTS IN THE CURING OF TOBACCO LEAF WITH THE ASSISTANCE OF ETHYLENE GAS.

(A. SHARP, Tobacco Adviser.)

During 1937, information was received from the Imperial Institute of Agriculture regarding the beneficial results which had been obtained experimentally in Germany and Italy from the use of a number of "narcotic" gases such as Ethylene, Acetylene and Nitrous Oxide in the curing of tobacco leaf.

The effect of very small quantities of ethylene gas on the ripening of fruit is well known, and this gas is now being used commercially in this State for the artificial ripening of citrus fruits, bananas and pears. The effect of the gas on the ripening of fruit is recognised to be due to stimulation of the enzyme processes, and, since the changes which take place in tobacco leaf during the curing process are also the result of enzyme action, it had been suggested that the quality of the leaf might be favourably influenced by the action of ethylene.

It was therefore decided to carry out a series of experiments with ethylene gas at Manjimup during the 1938 curing season. Very little information was available regarding the technique of using the gas except that the temperatures varied from 20 deg. to 28 deg. Centigrade, with atmospheric humidity from 75 per cent. to 90 per cent., and the proportion of ethylene to air in the curing chamber usually varied from 1 in 5,000 to 1 in 10,000.

The Department's curing kiln at Jardee was utilised for carrying out preliminary trials with the gas. A length of rubber tubing was led under the wall of the kiln and its outlet supported at the centre of the floor. The outside end was connected to a 30 inch cylinder of ethylene gas through a gauge which measured its output.

The first kiln to be cured was filled with ripe leaf from the Department's fertiliser and variety plots, and, during the yellowing process, a quantity of ethylene gas equal to 1/5000 of the cubic capacity of the kiln was introduced hourly. Yellowing was started at 85 deg. F. and the temperature was gradually raised to 100 deg. in about 27 hours. As the kiln contained leaf from six varieties of tobacco it had been anticipated that considerable difficulty would be encountered in getting each variety to cure satisfactorily owing to the tendency of certain varieties such as "Sport" to yellow more rapidly than "Hickory Pryor". It was found, however, that all six varieties yellowed at approximately the same rate, and all had developed sufficient colour 27½ hours from the commencement of the cure to enable ventilators to be opened and the fixing process to be commenced. It was considered that the time taken by the leaf to colour up was somewhat less than would have been the case without ethylene, particularly in the case of "Hickory Pryor" leaf. The application of gas was discontinued when yellowing was complete, and the remainder of the cure was carried out in the orthodox manner.

The leaf used in this preliminary trial was grown on moist flat country, and, being thoroughly mature, would be expected to present little difficulty in curing a good colour without the use of ethylene. It was desired to test whether the use of gas was likely to be advantageous in the case of leaf grown on hillside land. Such leaf is frequently of heavy texture, tending to coarseness, is more or less damaged by scorching, and usually fails to yield a high proportion of bright leaf.

Arrangements were accordingly made with Mr. G. F. Combs to purchase sufficient uncured leaf of this description to fill two curing barns. Two barns of similar size and construction were made available by Mr. Combs. The leaf was picked on 15th and 16th February, and the barns filled simultaneously. Curing was commenced at 5 p.m. on the 16th. Ethylene gas was introduced to one barn at the rate of $\frac{1}{2}$ cub. ft. every hour. This quantity was approximately $\frac{1}{5000}$ of the volume of air in the barn. As the barn was constructed with bag walls treated with cement wash, and had not been built to be specially gas-proof, it was considered advisable to admit fresh gas at hourly intervals in order to maintain the concentration. No ethylene was introduced into the "control" barn.

The yellowing process was carried out at a temperature of 90 deg. rising to 95 deg. in 36 hours. By this time the yellow colour was considered slightly more pronounced in the ethylene treated barn, but it was becoming obvious that neither barn was going to yield a good colour of leaf. Yellowing was continued until 6.30 a.m. on the 19th, 61½ hours after commencement of the cure. Neither of the barns had developed a good colour, most of the leaf in both having shown a tendency to go from green to a dirty brown colour. From experience gained later in the season, it is considered that this leaf had been adversely affected by a series of extremely cold nights prior to picking, although the damage did not become apparent until after curing had started. Curing of both barns was completed by noon on 21st February, and the leaf was bulked the following day.

Grading of the leaf was carried out about the middle of July, and, as was expected, only a very small proportion of the total quantity could be graded as "bright."

The following table gives the result of grading:—

				Total Weight of Cured Leaf.	Weight of Bright Leaf.	Percentage Bright.
				lb. oz.	lb. oz.	%
Barn 1—Control	...	...	...	281 12	6 2	2.17
Barn 2—Treated with Ethylene	...			299 15	8 1	2.68

It will be noted that the use of ethylene did not result in an appreciably higher proportion of bright leaf.

In order to determine whether the use of the gas effected any improvement in smoking quality, samples of leaf from both barns were forwarded to the Council for Scientific and Industrial Research, Canberra, to undergo smoking tests. The smoking test report has just come to hand and it indicates that, so far from improving the leaf, the use of ethylene has had a detrimental effect on aroma.

It may be that the use of ethylene gas in curing involves some modifications of orthodox flue curing practice to obtain satisfactory results, and in this respect further experimentation is necessary. On the other hand it has now been clearly demonstrated over a number of years that leaf grown in the Manjimup district on suitable soils and allowed to mature thoroughly in the field before picking, can be cured a bright colour, and with quite satisfactory smoking qualities, without any adventitious aids, and thus it is unlikely that the use of ethylene, or any other gas, will ever become a standard practise in tobacco curing in the Manjimup area.

THE MOULT AND FEEDING OF THE YEARLING HEN.

By G. D. SHAW,
Poultry Adviser.

Moult.—Fowls and other birds have an annual reconditioning of the plumage, and they will, at this period, cease laying eggs. Odd birds have the stamina to produce while in the moult, but these are exceptions and are not considered in this discussion.

The growing of new feathers yearly after the old and worn feathers have dropped is called the annual moult.

The moult is nature's method of dressing the fowl in new fashion previous to the period of reproduction. All old feathers are discarded and new ones are grown. The time during which this reconditioning is taking place is called the "moulting period" and this period may extend from as long as four months to as short as six weeks.

Apart from the annual moult it is possible that the fowls may pass through partial moults, for example:—When the early hatched pullets go into the neck moult in autumn and when at other periods the birds have received a check through sickness or possibly due to the distress of a heat-wave.

The longer a bird will lay into the autumn the quicker she will be in passing through the moult, and it can therefore be seen that the later the moulter the better the layer. On the other hand the early moulter is generally a poor producer and should be culled as soon as she is noticed going into an early moult.

We must refer to the article on "Culling" Spells "Profit." When we have found the poor producer ceasing to lay, at between November and early February, we have been advised to cull her because she will be eating into the profit. With this poor layer it will be noticed that the comb is shrinking up and is getting very hard in texture. Although she will not then go into a moult she will hang in this condition for months and from about the first week in February she and her sisters of like kin will then begin to cast feathers. This casting of feathers will be noticeable in the unculled flocks while in those flocks whose owners have learned the value of culling out the poor producer the moult will not be evident until about the early March or even later (this depends on the severity of the culling).

In this article it is not intended to give the details of the procedure of the moulting of the feathers. Suffice it to say that all the feathers will eventually fall and their places will be taken by a new growth, and so the bird will be in clean feathering before she begins her new laying season.

Three Kinds of Moulter.—There are three kinds of moulters. First of all, the continuous moulter, the one which appears to have clean unworn feathers throughout the year. This bird will generally fall into the class of layer called the "Dud." The next class is the early moulter. This class contains all those birds which are renowned for their short laying season. Into this class are those which cease laying about the November and then wish to rest until the following July. The next class is that of the late moulter. This class contains all those birds which have laid heavily for 12 months and moult quickly and are then ready for the next year's lay at about the same time as her sisters who have been in the moult for a much longer period.

In Western Australia the continuous moulter and the early moulter are now few and far between. Producers in Western Australia have taken the culling to heart, and on very few farms which have had the benefit of a culling demonstration,

will there be seen any birds of the two before-mentioned classes. They have been culled out months before the annual moulting period is at hand.

Late Moulter.—It is the late moulter we wish to study. We should be able to assist her to “come through” the moult with as little strain as possible. For a strain it is, and all possible assistance should be given to the bird.

The late moulter has been laying for twelve months. She has been kept in good condition by the judicious balancing of the feeds in the rations. She is not showing any undue strain due to her heavy laying, and if she is assisted through the moult she will continue to give eggs for another nine months. And in numbers equal to that laid by her in the previous corresponding nine months (from the July to the March).

During the period of heavy laying we have been feeding so that the body has been kept in the best of condition, and we have also been giving sufficient food in order for the fowls to lay heavily without danger to the constitution. We have fed body and also eggs into the fowl, and she is responding with high production and good body condition. It is often questioned whether we should allow the heavy layer to continue in the lay until she elects to go into a natural moult or whether we should force the layers into a moult at some predetermined time each year.

When one culls out the poor producer at the moment it ceases profitable production, one will have, at the time of the moult, only good layers on the farm, and these layers should have production high enough to ensure each bird a place in the breeding pens (except for any defects which although they will not affect egg production are not desirable when the bird is considered as a breeder).

Forced Moulting.—If such is the case we should therefore see that the layer comes through the moult in the best condition possible for breeding, and to that end it is advisable to recommend that all the layers which are to be kept for another year should be “forced” into a moult, so that they will have plenty of time in which to recuperate and grow new feathers before they are required for the breeding pens.

It is therefore recommended that the layers are all “forced” into the moult at the end of March, and are then given a three months’ rest from laying. During this period they will have sufficient strain in the growing of new feathers without having to put up with the strain of laying at the same time.

Feeding the Moulting Hen.—If the food has been sufficiently balanced the birds will not be suffering strain from heavy laying. Their egg production will be in the range of 45%. Their ovaries and oviduct in full bloom. Feathers and eggs need protein, and if we are to have feathers, the production must nearly cease. While all portions of the rations contain some protein it is recognised that the only way to give a sure fluctuation of the protein content in the ration is to increase or decrease the highly concentrated animal protein. In Western Australia the only proteins available in high concentrated form are the meatmeal and the dry buttermilk. In all references to the alteration of the protein, meatmeal is therefore the means applied when mentioning protein. The buttermilk is left consistent.

When there is any reduction in the proportion of protein in the ration, it is evident that the production will suffer. So that at the period near the end of March we have a favourable condition for causing a “forced” moult. The birds are near the natural period of moulting and they are easily forced out of lay. If the protein in the ration be reduced it is certain to affect egg production, and the

birds will then start to drop the old feathers, and egg production will practically cease. The one danger to remember is that the growth of new feathers consumes as much protein as does the production of eggs. Therefore, if the protein is reduced in order to ease off egg production it is evident that *once the feathers start to drop we will have to replace the protein* so that the bird will be able to grow new feathers without undue strain.

Assuming that we have a flock of layers "well culled," and laying the 45% so desired in March. In order to cease the production the protein (meatmeal in Western Australia) will be withdrawn from both the morning mash and the dry mash. This feeding will continue until there is shown a marked decline in egg production. With well fed birds the waiting will continue for about three to four weeks. In other cases one week only is sufficient. After the production has shown a sharp decline the birds *must be given a ration similar to that fed to them when they are in heavy lay*. The birds are now making new feathers and to do this satisfactorily they want high percentages of protein in the rations. *Do not starve the moulting hens*.

The days of starving the moulting hens are past. When one realizes that the feathers contain a high percentage of protein, one can then feed that ingredient to the birds, and so assist the growth of the new feathers. Any starvation at this period will only prolong the moult, and cause a severe strain on the constitution of the bird. The bird will not then be satisfactory as a breeder, and also she will take a longer period in which to complete the moult.

Should the Hens be Forced Into a Moult?

It may be questioned whether the forcing of the good layer into the moult will be as profitable as allowing the birds to take to the moult naturally. Eggs are at a high price during March, April, May and June, and any loss of production at this period may be a severe drain on the finances of the farm.

Against this is the production of the young laying pullets which should *all* be in full lay in March onwards.

If we are to take the long view and realise that the bird which has laid heavily for twelve months, and is also expected to continue to lay heavily for another year, must be in the best of condition all the time in order to stand up to the strain, we will appreciate that a rest of two months and the loss of the eggs during that time is more than fully repaid when the bird starts in June and *can* continue heavy production for another year. The bird which is allowed to lay herself out will not come into the lay as soon as those which have been made to rest and she will not be as strong as her sister which has the extra two months' rest. Give the rest and the bird will be able to lay into the next winter whereas if they are not rested you will find that they will fade away about the November and December of the year. Of course, a few exceptional birds will be able to carry on. But a few exceptional birds will not be as profitable as a lot of birds which can carry on because they have been allowed to recuperate for two extra months.

Therefore make the layers moult in April. Reduce the protein until the egg production has declined and then feed on the high production rations.

Let us now examine the flock of hens which are beginning the *forced April moult*. They will be laying 45 per cent. production and the protein is reduced in both the wet and dry mashes. The egg production will continue for a fortnight or three weeks, and then a sharp decline is noticed. Immediately this happens the proteins are again added to the rations. The birds will drop their old feathers and they will be under no undue strain during the regrowth.

Cull During the Moul.—Soon one will notice that some of the birds have drifted into the "dud" class of layer. Their comb has shrunk up—their body has also shrunk up—the comb appears as if it has been drawn into the head—the beak seems as if it has grown longer, and the eyes are taking on a shrunken look—a typical "dud"—and so it is. This bird has ceased to be profitable, and if kept will take until the following spring before coming into the lay again. On the other hand the sisters which have retained the supple comb (although the colour has faded) will have the large body showing capacity (width and depth). The eyes will be bold and the beak short and strong. Open up one of each class, and this is what you will find. The "dud" will show that the ovaries have dried right up, and will be about the size of a pea, while the other bird will give you the distinct opposite. The ovaries will show an effect similar to a bird in full lay. The yolks will be in some cases fully developed and graded down showing that the moult has been no strain, and as soon as the feathers have been fully grown the food will then be transferred from feathers to eggs in the shortest possible time.

It will be noticed that the birds which do not collapse will begin the lay practically simultaneously. The percentage of production will rise from the nominal 5% during this moult to the desired 60% in about four weeks. In plenty of time for those birds to be in the breeding pens and with a supply of eggs sufficient in quantity to keep the incubators fully supplied in the early portion of the hatching season. On the other hand, if the birds are to go into the moult naturally, they will come out of the moult naturally, and time taken to reach the heavy lay again will be too long to be of much use in keeping the machines filled in the early part of the season.

Health of the Flock During Moul.—It will be noticed that in the whole process, the health of the flock has been the main consideration. Ease the lay by reducing the protein. Add the protein when egg production eases, and feathers are dropping, and the birds will respond quickly. Let the birds lay themselves out, and there is a strain on the constitution which takes times to repair. Time which is too valuable to waste.

It is therefore considered more economical to force the moult in April than to allow the birds to abide their own time.

It must be understood that the bird which breaks down when going through the moult of April to June is of little use on the farm. She should be considered similar to her younger sister who will not lay enough eggs to pay for her feed. Cull the bird which takes on the form of the "dud." And all those which are left in the flock will lay a percentage of eggs in the same proportion as the young pullets month for month.

If the flock has been continuously culled as suggested in the article "Culling Spells Profit," the numbers at the end of the first moult will be about 50% of those which were placed in the pens as good pullets fifteen months before. But every bird has been a profit earner for every month in the year (except during the moult). During the moult the birds are consuming food for which they must eventually pay, and their means of paying off that debt is by the eggs they will lay during the next season. Therefore, the sooner they come into the lay in June, and the longer they can sustain that lay, the greater will be the profit. It will be realised that the moulting bird is at a disadvantage, for she will begin her second season of egg production when the prices of eggs are dropping to a figure which is governed by London parity prices, and the profit of egg production over feed costs per week will not be as great as when she started fifteen months before when

eggs were 2/ per dozen. She has created another debt equivalent to approximately ten or twelve weeks at 2½d. and she has to redeem that debt before the farmer can consider he is receiving a profit.

It will be in the middle of September before the debt is paid. If any factor is allowed to lengthen this time for redemption the longer the farmer will have to wait for his share of the profits.

Feeding the Hen.—When the bird is through the moult it can be suggested that it will not be as active as the younger bird, the pullet. It is also a well-known fact that the older the bird the greater tendency to place on fat. We must, therefore, retrace our steps and again study *How to Feed Your Fowls*, Journal of Agriculture, Vol. XIII, Page 465. It was explained that the bird should have a ration so balanced to meet all the requirements of body and eggs.

The Requirements of Body and Eggs, and therefore, we are asked to study the requirements of the yearling layer. The hen which has passed through the first moult is now ready for the breeding pens. She has proved that she can give twelve months good production and has gone through the moult successfully. But she has reached a more benign stage, she is not as flighty as her younger sister. Therefore, she will not be able to use the energy forming portions of the rations as quickly as the younger sister. She will then store up the surplus, and in storing up the surplus will immediately begin to get fat. Layers of fat in all parts of the body. The fact that the fat is being stored up through a too high percentage of fat forming foods in the ration naturally must suggest that the protein is in short supply; and the protein being short supplied will immediately be evident in the percentage of egg production. If under any circumstances the bird places on fat, the egg supply must suffer, and more so when the bird has passed the first moult. Therefore, if the bird is going to put on fat the egg production is reduced due to a lack of sufficient protein in the food.

If one takes the trouble to notice a flock of white leghorns, one will notice that the young pullet will be in good condition, and will be laying well while the older bird will be placing on fat, and will not be laying as well as she could. This immediately suggests that the food for the pullet is not the correct food for the hen. And such is the case. The older bird being less active will not be able to consume the same percentage of energy forming food as the young, and more flighty pullet. Therefore, in order to balance the ration for the older hen the protein *must* be increased in proportion. It has been found that the yearling hen, or the hen after her first moult will need approximately 25 per cent more meatmeal in the ration than that necessary for the pullets. In order to ascertain this figure the suggestion given in "*How to Feed Your Fowls*," page 468 is used. The dry mash is used when endeavouring to effect a balance. We are to keep the one mixing of the morning wet mash for all breeds and ages, and we are to balance the rations for breeds and ages by the addition of extra protein to the dry mash hoppers. The bases given are ½ measure of meatmeal for White Leghorns.

⅝ measure of meatmeal for Rhode Island Reds.

11/16 to ¾ measure of meatmeal for Australs and other heavy breeds.

These measurements are for the pullets. Those who have used these measures have found that they are satisfactory for the pullets, but are low for the hen. The suggestion has been invaluable for demonstrating the necessity for extra meatmeal when feeding birds in their second and third year.

An example of extra feeding of meatmeal to the older hens compared to pullets is given. At a farm in the country it was pointed out that the pullets were doing

80 per cent. lay, while the hens were not above 55 per cent. during the spring peak (September). On handling the birds it was found that the hens were carrying too much fat, and the farmer was advised to increase the meatmeal by 25 per cent. for about seven days, and watch the result. The farmer accepted the advice, and seven days later gave the results.

At the time of the visit	50 per cent.
First day after	50 " "
Second day after	52 " "
Third day after	56 " "
Fourth day after	67 " "
Fifth day after	70 " "
Sixth day after	73 " "
Seventh day after	77 " "

The slight addition of meatmeal thereafter continued to give the extra results. The farmer was convinced of the necessity of extra meatmeal for the hens. The birds were Leghorns.

When the White Leghorn passes through the first moult the proportion of meatmeal to be used in the dry mash can be as high as $\frac{5}{8}$ measure instead of the $\frac{1}{2}$ as for the pullet.

When the Rhode Island Red passes through the first moult the proportion of meatmeal to be used in the dry mash can be raised between $\frac{11}{16}$ to $\frac{3}{4}$ measure, whilst the proportion for Austral yearlings is in the vicinity of one full measure.

If the methods of ascertaining the proportions required are based on the practice as suggested in "*How to Feed Your Fowls*" page 469, poultry farmers will have little difficulty in keeping the fat down and the egg production up.

It must be understood that the bird which has passed through the second, and for that matter, any other subsequent moult, will be still more liable to place on fat, and therefore the proportions of meatmeal must be increased after each moult. Birds which have been fed a properly balanced ration for several years, are still in good fettle and the egg production is comparable to that of the pullet beginning the first year.

Unfortunately, the second, and any subsequent lay, is only for the months of July to March (nine months) while the first year's lay extends for the period, February or March, to March.

2nd Year Culling.—After the hens have completed the moult and are laying, the farmer should continue to *cull* as was performed during the first year of lay. The hens will produce in approximately the same percentage as the pullets, if one has already eliminated the *dud*. (This *dud* should be culled during the process of the moult.) The sprinter will again show up and should be culled out as soon as she ceases profitable production. It is here the farmer should concentrate. As the hen has approximately only nine months of laying, it is not profitable to allow the hen to stay on the farm one day too long. The farmer has had one year of culling, and is becoming proficient in anticipating the "fence sitter." This bird will have the comb which has a texture similar in feel to the top portion of the human ear, and the moment it "falls off the fence" the comb will begin to take on the feel of felt. It will then begin to show up as if it were a "*dud*." It is here the farmer should concentrate. He knows what is going to happen and he should inspect closely for any signs suggesting a fall in production; the bird is then

culled. It will be found that the reduction in the flock will be similar to the reduction in the pullets. And by the time the second moult is completed, the flock of hens will have dwindled to approximately half that of the previous July. The percentage of culling during the third year is heavier than that of the second year, and as the birds grow older the percentage of culling increases.

Partial Moulting.—Apart from the annual moult, the birds are apt to have what are termed false moults.

Firstly, the young pullets may suffer a partial moult in the first autumn. This may be due to change of management, such as the change of food, or a change of housing when the pullets are beginning to lay. Any sickness in the March to June period may be the cause of a partial moult. And in all cases the partial moult may develop into a full moult. In all cases the moult will cause financial loss to the farmer, and all practices should be adopted to carry the birds through the season without a relapse into a moult which is not natural to them.

To this end it is advised that the pullets should be shifted to their laying quarters as soon as possible. If the shift takes place before the pullets are five months old they will have sufficient time to settle down and become comfortable in their new quarters. They must not be overcrowded, for overcrowding will cause distress, and any distress may be considered sufficient excuse for a moult. See that the pullets are fed sufficient food. Many a partial moult is caused because the pullets are fed insufficient food. They have been well reared from the chicken stage, and are in the best condition for a heavy lay; therefore, if for any reason the food is insufficient the pullets will not be able to obtain the amounts necessary for high production. As they have been bred to lay they will draw on the body for any deficiency and the constitution will suffer. The pullets will then go into a partial moult, and in some cases a full moult will take place—with eggs at 2s. per dozen. The pullets should be treated gently. Any frights will have a tendency to induce a partial moult.

Hanging in the Mould.—When the fowls have moulted producers are inclined to expect the birds to lay immediately the new growth of feathers have begun. In some cases the hens have been condemned as “hanging in the moult.” At this stage we must be prepared to consider whether the birds are ready for the lay, or whether they are still growing the feathers. The birds are not ready for laying until they have completed the growth of the new feathers, and the farmer would be well advised to handle the fowls to see the progressive growth of the feathers.

It is of little use expecting eggs until the growth ceases. On the other hand it is not unusual for the hens to “hang in the moult,” and this can be remedied if the farmer is prepared to realise that perhaps the feeding is not quite right. When there is any doubt that the birds are “hanging in the moult” it is best to examine the feather growth. If the growth is complete the birds are ready to lay, but if the ration is not right the birds cannot lay.

If the feathers are grown and the farmer is perturbed because the birds are not in the lay it is an easy matter to find the cause. The addition of more meatmeal in the morning mash will generally find the fault.

Extra Meatmeal.—It is advised that for three or four days in succession the meatmeal should be “doubled up” in the morning mash, and then revert to the base. After a period of about three or five days the birds should show egg production: it is a sure sign that the protein proportion of the ration is a little on

the low side, and has been short supplied for the period of the moult. There will be an immediate response if the feathers are fully grown, and that response is a definite guide of shortage of egg-forming ingredients in the rations. The farmer should then study the ration, the laying condition of the bird, and the colour of the droppings. All three will be factors in determining the amount of meatmeal required.

If, on the other hand, the birds do not respond to the extra ration of meatmeal, the farmer can be sure that the feathers are not fully grown.

Birds coming into lay can be similar to the runner—they will wait for the starter's gun. In this case the starter's gun is the extra ration of meatmeal.

An example of the lay of a well-culled flock of hens passing through the moult. These hens had been forced to rest from the first of April, and the laying was as follows:—

June	1st	7th	14th	21st	30th
eggs	12	12	30	50	58
July		7th	14th	21st	31st
eggs		58	62	68	72

These hens were apparently through the moult about the 7th June. All hens were laying on the 30th March, the production being 46%.

If your hens are not all laying in the beginning of July, add the extra meatmeal, and closely watch the results. It should be followed by a marked increase in the production of eggs. Thereafter apply this practice whenever the birds are not laying up to expectations. Should the response to the extra meatmeal be sudden, you can be sure the meatmeal has been a little low in proportion to the other ingredients. If there is no response you may be sure your birds need "culling." *It is necessary to remember that the continued use of double amounts of meatmeal is dangerous.* Whilst on the other hand the doubling up now and again is the farmers' method of checking the feeding management.

Natural Moulting.—Having dealt with the hens which are to be kept for another year, and explained how they are to be managed through the moult, it will be evident that at some period in the management of the farm the farmer is determined to dispose of the aged hens at the end of the current year. When this is decided it will be found advantageous to allow the bird to lay for as long as possible. The extra eggs at increasing prices are so much more profit, and no attempt should be made to force the birds out of production in April. It should be the aim to keep the bird in production for as long as possible, and to that end the farmer should slightly increase the meatmeal, and also the buttermilk. Note: This is the only time the buttermilk is increased for laying flocks. These two increases will tend to force a few more eggs out of the hens at the time when they are due for the annual rest. The increases should begin about December and continue until the moult is well established.

Disposal of Stock.—Do not wait for the full moult before disposing of the stock. As they go out of production send them to market and so have them in reasonably good feather. If the farmer waits until the moult is well advanced he will not receive as much as if they were carrying feathers. Should the farmer delay the disposal until the new feathers have arrived he will not be repaid for the extra feed and trouble entailed. It is advisable to *send to market immediately the bird is going out of production*, and before the feathers have started to drop.

HARVESTING AND CURING OF TOBACCO LEAF.

A. SHARP, Tobacco Adviser.

Under normal conditions at Manjimup the bottom leaves will be ready for harvesting about three months after the planting out of the crop. In the case of a crop planted about the middle of October, harvesting can be expected to commence about mid-January and continue until about the end of February.

The method of harvesting by cutting the stalk at ground level and curing the whole plant at once is no longer practised in the case of flue cured tobacco. The tobacco plant ripens progressively from the base upwards, and it is therefore obvious that, with this method, the leaves would be in various stages of maturity. In order to meet the somewhat exacting standards set by the manufacturers today, it is essential that every leaf picked should be as nearly as possible of the same degree of ripeness, and this is possible only by harvesting by the method known as "priming," whereby each leaf is picked separately from the plant as it ripens. Four to six pickings may be necessary, and a period of four or five weeks or more may elapse between the first and last pickings.

It is extremely important that the tobacco grower be able to recognise the proper stage at which the leaf should be picked. Probably more leaf is spoilt every year through being picked in an immature condition than through any other cause. Exact knowledge on this point can be gained only by experience. Generally speaking, ripening is shown by the colour of the leaf changing from dark green to a characteristic yellowish green. Just how far this yellowing ought to be allowed to go before picking will depend very largely on soil conditions and on the texture of the leaf. Very heavy bodied leaf frequently assumes a mottled appearance on ripening. Mature leaf also tends to become somewhat brittle, and on being folded between finger and thumb it snaps along the fold.

Under the very hot and dry conditions experienced in this State during harvesting, it frequently happens that crops grown on soils which have failed to retain sufficient moisture, or in situations exposed to hot, drying winds, fail to mature normally. The tips and edges of the leaves turn yellow and then brown through scorching while the rest of the leaf remains dark green. It is sheer waste of time and money to pick and cure such leaf as it does not colour properly in the curing barn, its smoking quality is very poor, and the manufacturers refuse to purchase such leaf at any price. The only advice that can be given in such a case is to cut the loss incurred in growing the crop, pull up the plants and burn them, and do not attempt to grow tobacco again on that particular area.

It cannot be too strongly emphasised that careful picking of the leaf is absolutely essential if success is to be obtained in curing. A careless picker can cause an enormous reduction in the value of the finished article, and those growers whose operations are on a scale sufficiently large to necessitate the employment of a number of hands would be well advised to spend some time at the beginning of the harvesting season in making sure that the pickers know exactly the proper stage of maturity at which to pick. Their work should be very closely supervised and the adoption of a system of periodically checking up the work of each individual picker would tend to keep the standard of work reasonably high.

The best time to pick is in the early morning from six o'clock to about ten. The leaf is then fresh and crisp, and the work is much less fatiguing than is the case in the heat of the day. Care should be exercised in the handling of the leaf to avoid bruising, and it should not be exposed to the sun's rays longer than is absolutely necessary as undue exposure causes wilting and scorching. The presence

of dew on the leaf will not matter provided that it is strung on the sticks and hung up within a few hours. Should a fairly heavy fall of rain occur during the harvesting period the gum which is normally present on the leaf surface is liable to be washed off. Picking should not be resumed until two or three fine days have elapsed, by which time this gum will again have made its appearance.

PRIMING.

The usual procedure is for the picker to break off the leaves separately from the stalk and place them in the crook of one arm with the butts pointing in one direction. When as many have been picked as can be conveniently carried in this manner they are placed carefully on sheets of hessian previously placed at intervals between the rows. When the sheets are full, the ends are brought over and hooked together to form a bundle, and they are placed on a cart or truck and taken to a stringing shed. An improvement on this method of transport is to provide hessian stretchers, about the same size as the ordinary ambulance stretcher, on which to place the leaf. These, when full, can be placed on the cart and, on arrival at the shed, can be slid on to the stringing bench. The use of these stretchers enables the leaf to be handled expeditiously with a minimum of cracking and bruising.

STRINGING.

The stringing shed is usually a more or less temporary erection of hessian stretched over bush poles and situated close to the curing barns. Its purpose is merely to provide shade for the leaf until it has been strung on the hang sticks and placed in the barn. The leaf is placed on benches in this shed with the butts pointing outwards. Conveniently placed to these benches are stands which support the ends of the hang sticks while the leaf is being strung. These sticks are usually about 4ft. 6in. long, and two types are in use in this State. The more popular type consists of 1½in. x 1in. hardwood fitted with a number of cross wires of 12½ gauge galvanised steel fencing wire, 18 to 20 inches long and spaced six or seven inches apart. The leaves are strung on to these wires by the fleshy butts of the midribs, care being taken to leave a small space, say quarter of an inch, between each butt. It is advisable to string the leaves back to back and face to face on these wires in order to facilitate the passage of a current of air across their surfaces during the curing process.

Another type of hang stick, which is less popular here although it is used almost exclusively in the Eastern States, consists either of sawn hardwood of similar dimensions to that previously described or of bush poles about 1½in. in diameter. The leaf is hung from the stick by means of ordinary grocer's twine which is fixed about four inches from one end and looped round the butts of the leaves which are arranged in pairs, back to back, on alternate sides of the stick, the string passing over the stick in zig-zag fashion, and being secured four inches from the other end by a couple of half hitches. There is some difference of opinion among growers as to which type of stick allows of the more rapid handling of the leaf.

When sticks are filled they are carried carefully into the curing barn and suspended between the tier poles. It is essential for first class results that the barn be filled and the curing process commenced within a few hours of the picking of the leaf.

THE FLUE-CURING BARN.

During the flue curing process the leaf is subjected to varying degrees of temperature and atmospheric humidity, and a properly designed curing barn is one in which these factors can be regulated within reasonably close limits, irrespective of the atmospheric conditions obtaining outside the barn.

In the modern flue curing barn the temperature is regulated by a heating system consisting of one or two brick furnaces connected to a series of sheet iron flue pipes running across the floor, and exhausting into one or two chimneys. To assist in the conservation of heat and to avoid sudden fluctuations of temperature due to outside weather conditions, the walls and roof are built of some material which is a good insulator of heat. The degree of humidity is regulated by adjustable ventilators at ground level and in the roof.



Fig. 1.—Tobacco-curing Kiln erected to the writer's design at Manjimup for experimental work by the Dept. of Agriculture into the techniques of tobacco curing.

Photo. by Author.

SIZE OF BARN.

The size of barn which will be found most convenient will depend largely on the area of crop to be cured and the amount of labour available. In this State, most of the tobacco plantations are comparatively small, usually from 5 to 15 acres, and rarely exceeding 25 acres. For small plantations, say, up to 15 acres, a number of small barns, each 12ft. by 12ft. inside measurement, and carrying four tiers of leaf, will be found most suitable. For areas greater than this, barns 16ft. by 16ft. with four or five tiers may be used.

The writer is very definitely in favour of the small barn. It is essential for good results that curing should start within a few hours of the leaf being picked, and the small staff which can be economically employed on the small plantation can fill the smaller size barn comfortably in one day, whereas two or more days would be required to fill the larger size. It is frequently found, also, that two or more distinct types of leaf may be grown on one plantation owing to variation in the soil or some other factor. These different types require different treatment during curing. Where small barns are provided they can be cured separately, thus enabling each to receive any particular modification of the curing process which it may require. In order to fill a large barn from a small area of crop, the grower is frequently tempted to harvest leaf which is slightly immature, a practice

which cannot be too strongly condemned. Immature leaf will not cure properly and is unsaleable. Where several small barns are provided picking can be done more frequently, thus permitting of a more evenly matured sample of leaf.

Generally speaking, one 12ft. by 12ft. barn will be sufficient for each four acres of crop, while a 16ft. by 16ft. will deal with each seven acres. While the capital cost of a number of small barns is greater than that of a smaller number of larger units having the same aggregate capacity, the higher proportion of bright leaf obtainable by the use of the former will more than repay the extra outlay.

The barns should preferably be built in a fairly well sheltered position on slightly sloping ground, the furnaces being built on the lower side in order to lessen the amount of excavation necessary. The accompanying sketches show the construction of a 12ft. by 12ft. barn to hold four tiers of leaf. A 16ft. by 16ft. barn would be built on precisely similar lines except for the arrangement of furnaces and flues.

MATERIALS.

Various materials may be used in the construction of the barn. The framing should consist of 4in. x 2in. jarrah, with wall studs set at 2ft. centres. This may be lined with either wood, corrugated iron, asbestos-cement sheets, or used fertiliser or wheat bags sewn together and treated with cement wash. The last named is the cheapest and is regarded as being more or less a makeshift, but it is very largely used in this State at present, and, where double bag walls well coated with a suitable cement wash have been used, good results have been obtained.

FORMULA FOR CEMENT WASH.

The following is a formula for cement wash which has proved quite satisfactory:—

- 1½ gallons water.
- 12 lbs. cement.
- 2 lbs. lime.
- 1 lb. salt.
- ½ lb. alum.

Sieve salt and lime together. Add this to the water, then follow with cement, stirring while adding. Finally add the alum. Apply this mixture immediately with a fairly stiff brush, first wetting the bag wall. Two coats of wash are required, and the first coat may be made slightly thinner than the above.

Whatever material is used, it should be attached to both the inside and outside of the framing, and the heat-retaining qualities may be still further improved by filling the space between with dry earth or sawdust.

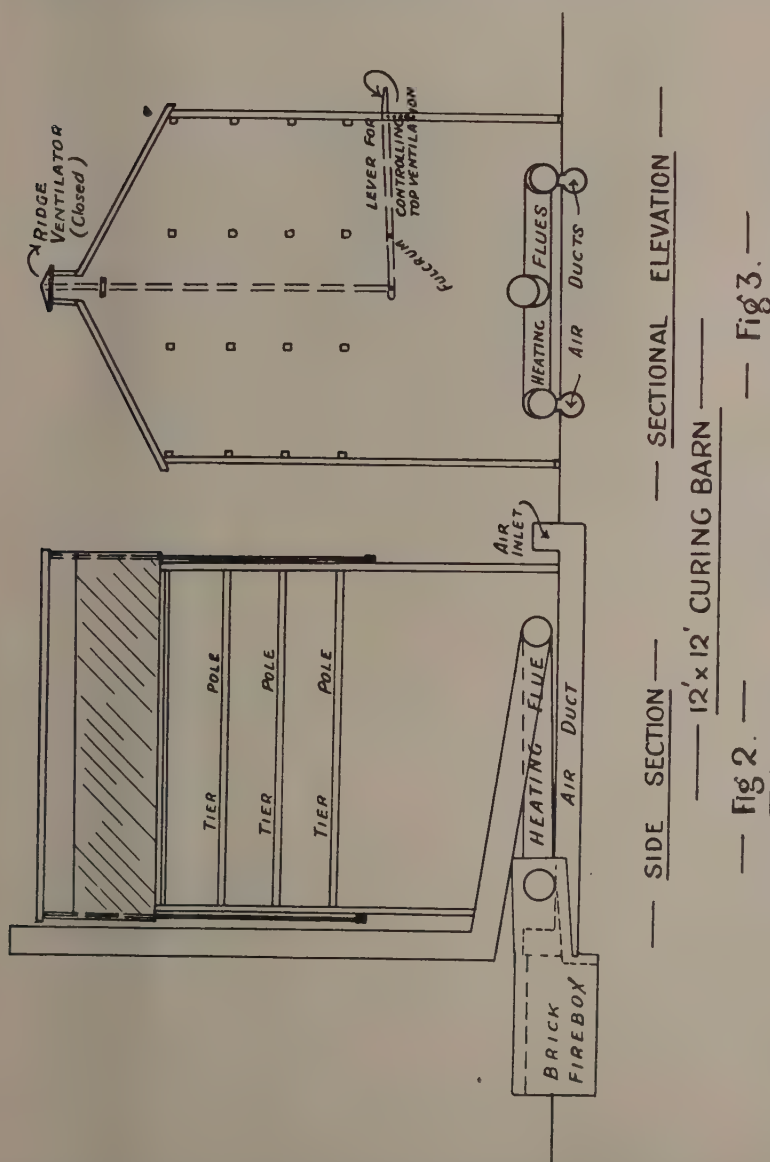
HEATING SYSTEM.

One brick furnace is capable of heating a 12ft. barn, but in the case of the 16ft. size best results will be obtained by using two. The firebox should preferably be built a foot or two away from the barn, and should be sunk below floor level so that a slightly sloping brick flue will connect it to the sheet iron flue pipes inside the barn just above floor level. These latter are usually about 11 inches in diameter and are made from 24 gge. galvanised iron. They may be arranged in a number of ways, the most usual being as in figures 4 and 5.

CONSTRUCTION OF THE FIRE-BOX.

The brick firebox is usually 18in. wide by 30in. high by 5ft. long, inside measurement. The walls should be 9in. thick and support an arched roof. The mortar should consist of a mixture of clay and sand, as this will withstand heat

far better than a cement or lime mortar. It is not advisable to incorporate iron arch supports as these expand when hot and may cause extensive cracking of the structure. To assist in controlling temperature a damper may be fitted at the base



Figs. 2 and 3. Drawings showing side section and sectional elevation, respectively, of open-ridge-ventilator type of 12ft. x 12ft. tobacco-curing kiln. For description of construction, etc., see text.

of the chimney, and it is advisable also to have a metal door at the mouth of the firebox. A piece of sheet iron held in place by a piece of timber or iron bar answers the purpose perfectly well.

VENTILATING SYSTEM.

A really efficient system of ventilation is essential. In the case of the small barns advocated for use here such a system can be constructed quite easily and at no great cost. It consists of two parts, an air inlet at ground level and an outlet at the apex of the roof. When the barn is in operation with both top and bottom ventilators open, the warm air inside the barn, being less dense than the cooler air outside, rises and escapes through the roof vent. Its place is taken by air drawn through the bottom ventilators, which in turn becomes warmed and rises. The steady current of warm air thus passing up through the leaf hung in the barn carries away the moisture given off by the leaf during the curing process.

The top ventilator should consist of an opening about one foot wide along the whole length of the ridge of the roof. A solidly constructed ridge cap made of timber covered with galvanised iron fits closely on top of the opening so that when closed it is as nearly airtight as possible. To open, this ridge piece is pushed up at each end by a perpendicular bar, sliding in an iron strap, and operated at its lower end by a lever working on a fulcrum. The amount of ventilation is regulated by an iron pin fitting into a series of holes, by which the lever is held in any desired position. This type of top ventilator is simple to construct and operate, offers the minimum obstruction to the egress of the moisture-laden air from the barn, and its efficiency remains constant irrespective of the strength and direction of the wind.

The best type of bottom ventilator consists of a series of ducts sunk in the floor of the barn immediately under the heating flues, and communicating at either end with the outside atmosphere through an adjustable shutter by means of which the amount of ventilation may be regulated. A narrow slit or series of apertures are cut in these ducts so that the incoming air is directed on to the hot flues and is thoroughly warmed before it can come in contact with the leaf.

SPACING OF TIER POLES.

The tier poles which support the sticks on which the leaf is hung are spaced at four foot centres. They may be made of bush poles or, preferably, of 4in. x 2in. sawn timber. The perpendicular distance between each tier should not be less than two feet, and the bottom tier should be at least 7 ft. 6 ins. from the floor. Thus a four-tier barn will require to be at least 14 ft. high to the eaves and a five-tier one 16 ft. If it is desired to allow more space between the tiers to accommodate very large leaf, the height of the barn will have to be made correspondingly greater. It is not advisable to have the tips of the bottom tier of leaf lower than 5 or 6 feet from the floor, otherwise they are liable to become scorched by the heat of the flues.

The door should not be less than 6 ft. 6 ins. high by about 3 ft. wide. It should preferably be fitted at the furnace end of the barn and should open outwards. It should be of solid construction and fit the doorway closely. It is a good idea to fit a small window about the level of the bottom tier so that a thermometer hung there can be read without the necessity of opening the door.

FLUE CURING.

The first thing that the tobacco grower must understand is that curing is not merely a drying process. When the leaf is placed in the barn it consists of living tissue in which certain chemical changes will continue to take place until the leaf is killed. These chemical changes are normally accompanied by a change in colour from green to yellow. The art of curing lies in regulating the temperature

and humidity of the atmosphere surrounding the leaf so that, just as the web reaches the desired colour, sufficient moisture has been extracted to kill it and thus prevent any further chemical action which would cause the leaf to turn dark. No known method of curing will convert poor or immature leaf into good leaf, but good curing will further develop and fix the desirable qualities inherent in properly grown leaf.

It is quite impossible to lay down any hard and fast formula for curing tobacco. The behaviour of the leaf in the barn is influenced by many factors quite outside the control of the curer, such as the type of soil on which it was grown, weather conditions during growth and during curing, variety, degree of maturity, and so on, and it is only by experience that a high degree of skill in this branch of the work can be acquired. An understanding of certain general principles, however, will assist the beginner considerably.

The process consists essentially of three stages, viz.:

1. Yellowing the leaf.
2. Fixing the colour.
3. Drying out the midribs.

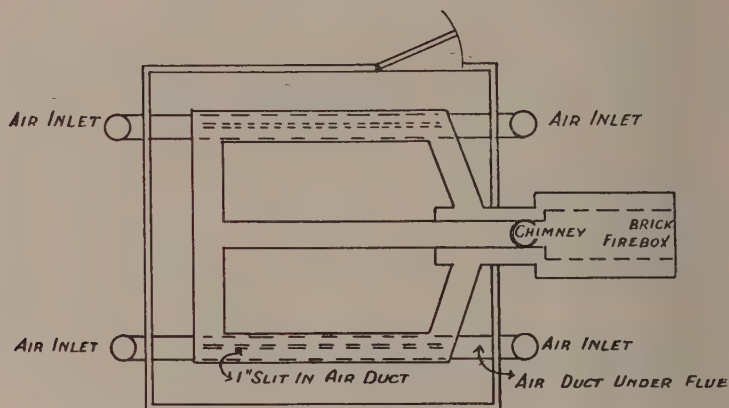
In order that proper control over these processes may be exercised it is necessary for the barn to be equipped with at least one thermometer and a hygrometer (wet and dry bulb thermometer). The latter indicates the humidity of the atmosphere in the barn. When the readings of the two columns are equal the atmosphere is fully saturated with moisture, and as the humidity decreases the difference between the readings becomes progressively greater, the wet bulb giving always the lower reading. Coloured spirit thermometers are preferable to those having a mercury column as they are more easily read at a distance or in a poor light.

YELLOWING.

Immediately the barn has been filled the door and all ventilators are closed and the fire lit. The temperature is raised to about 90 deg. F. and kept there. If the barn is well built and properly filled with freshly picked, unwilted leaf, the humidity will rise within an hour or so until there is a difference of not more than three degrees between the wet and dry bulb readings. This is due to the moisture transpired by the leaf.

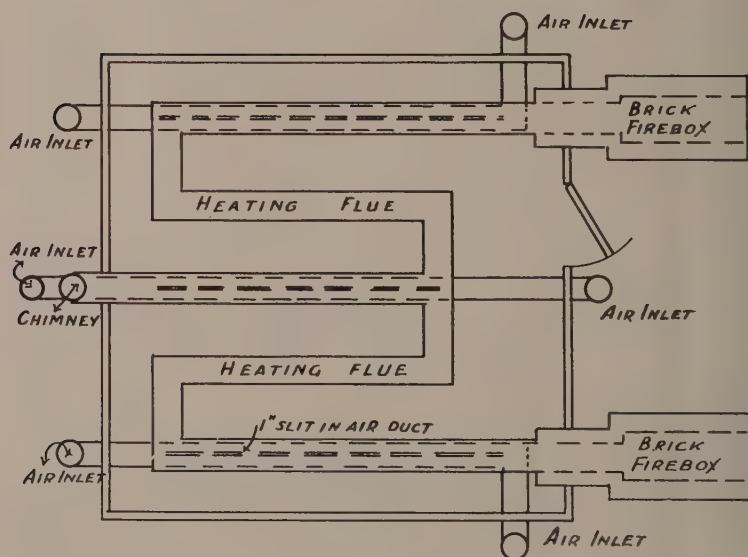
It frequently happens, however, particularly in the case of bag walled kilns, that this degree of humidity cannot be attained without the artificial introduction of moisture. This is usually done either by placing wet bags on the warm flues or by introducing low pressure steam from a boiler placed outside the barn.

The effect of the warm, humid conditions now obtaining in the barn is to greatly accelerate the ripening process which was begun before the leaf was picked. The rate at which yellowing takes place varies within wide limits according to the type of leaf being cured and the degree of maturity when picked. Anything from 12 to 48 hours or even longer may elapse before sufficient colour has developed to allow of the ventilators being opened and the second stage commenced. During this period, temperature may be very gradually raised to 100 deg., at which stage the wet bulb reading should be about 95 deg. or 96 deg. A knowledge of just how far yellowing should be allowed to proceed before commencing to fix the colour can be gained only by experience. Should fixing be commenced too early the leaf will cure out with a distinct green tinge to which the buyers object. On the other hand, should it be deferred too long, the bright yellow colour will turn to brown, with corresponding fall in the value of the finished article.



— GROUND PLAN of 12' x 12' BARN —

Fig 4



— GROUND PLAN of 16' x 16' BARN —

Fig 5

Figs. 4 and 5. Drawings showing ground plan of 12ft. x 12ft., and 16ft. x 16ft. tobacco-curing kilns, respectively. For description of kilns see text.

FIXING THE COLOUR.

It is at this stage that the ill-effects of bad picking become apparent. Fully mature leaf will now be quite yellow, that which was slightly less mature will still show a little green and really immature leaf will scarcely have begun to show any yellow at all. When the curer has decided that the major portion of the leaf is at the correct stage, the top and bottom ventilators are opened very slightly. Sometimes the top vent is opened an hour or two before the bottom ones with the idea that leaf which has reached the desired colour will commence to dry out, while that which still retains a tinge of green will be enabled to develop a little more colour.

Immediately on the opening of the ventilators, the humidity in the barn falls as will be shown by a gradually increasing difference between the wet and dry bulb readings. The most critical stage of the cure has now been reached. The object now is to gradually increase temperature and ventilation so that the web of the leaf is slowly dried out and killed as it reaches the desired bright yellow colour. At this stage the chemical changes taking place in the leaf cause moisture to be



Fig. 6.—Experimental Tobacco-curing Kiln and four other kilns embodying most of the characteristic features of the writer's design, but being constructed with bag walls, on the property of Mr. G. F. Combs, Jardee.

(Photo by Author.)

expelled from the tissues, and conditions in the barn should be regulated so that a current of warm and comparatively dry air is continually passing over the surface of each leaf and absorbing this moisture as it is produced. Should insufficient ventilation be given, or the air allowed to become too cold, this moisture, instead of being carried away, will be deposited on the surface of the leaf and the condition known as "sponging" will occur. This is indicated by a brown discoloration on the surface of the leaf which will greatly reduce its value if allowed to go very far. Should the leaf show signs of sponging, temperature and ventilation should be increased. Should this be necessary, however, a certain amount of skill is required in the handling of the fire as a sudden increase of ventilation, particularly at night, is liable to cause a drop in temperature with the result that the condition may be made worse. On the other hand, too rapid raising of the temperature should be avoided as this tends to cause reddening of the leaf through scorching.

The drying of the web is indicated by the edges and tips of the leaves curling and becoming brittle, and this condition gradually spreads inwards towards the midrib. As drying proceeds temperature and ventilation are gradually increased

until, by the time the web is completely dry the thermometer is standing at about 135° and the ventilators are full open, both top and bottom.

DRYING OUT.

The colour has now been fixed and it only remains to dry out the thick, fleshy midribs. This is done by raising the temperature about 5° an hour and progressively decreasing ventilation until at 160° the ventilators are nearly closed. The temperature is held at this point until all midribs are quite dry and will snap without bending. Having made sure that there are no soft midribs, particularly in the corners of the barn nearest the door and in the top tier, the fires can be drawn and the door and vents opened wide to allow the leaf to cool down.

The period occupied during the cure will vary usually from three to five days according to the type of leaf, and it will be realised, of course, that someone must be in attendance at the barn during the whole of this time.

CONDITIONING.

On completion of the cure the leaf is absolutely dry and brittle and if handled in this condition it would fall to pieces. It is necessary, therefore, to allow it to re-absorb a certain amount of moisture from the atmosphere before it can be removed from the barn. Owing to the very dry, hot weather usually experienced in this State during the curing season, it is frequently necessary to artificially humidify the atmosphere of the barn, either by introducing low pressure steam or by warming up the flues again and placing wet bags on them. If steam is used great care must be taken not to overdo it. As the leaf "conditions" it loses its brittleness and becomes tough and pliable and in this condition it can be bulked down. A certain amount of experience is required to know just how much condition the leaf should have when bulked down. About 12 per cent. moisture content is the ideal to aim for, and this is indicated roughly by the "feel" of the leaf. It should emit a slight crackling when handled and the midrib should retain a certain amount of brittleness for about one-third of its length from the butt end.

If the leaf is bulked down too damp it will go mouldy and will be completely ruined. When bulked down in proper condition a mild fermentation takes place which results in a considerable improvement in both aroma and appearance of the leaf. If bulked too dry this fermentation is retarded and no such improvement takes place. The beginner, however, should err on the side of bulking too dry rather than run the risk of having his bulks go mouldy.

BULKING DOWN.

The tobacco should be bulked in a well-built shed preferably set on stumps at least two feet off the ground. Should the floor of the shed be at or near ground level it is advisable to erect a platform about two feet high and bulk the leaf on this in order to prevent absorption of moisture from the ground with consequent development of mould. The usual method of bulking is to make a stack about 3 or 4 feet wide and any desired length and height. The leaf is stacked with the butts to the outside, and as each cure is added it is usual to place two or three fairly heavy planks on top to consolidate the bulk and exclude air as much as possible. It is advisable also to cover the bulks closely with hessian as a protection against sunlight and, later on, against excessive absorption of moisture from the air after the Autumn rains have set in.

DESTRUCTION OF STALKS.

The grower should not consider the harvesting of his crop finished until the stalks of the plants remaining in the field have been pulled up by the roots and

burnt. If left growing, these plants act as hosts for a number of fungous diseases and insect pests, and a regulation under the Plant Diseases Act is in force to the effect that all such unharvested portions of the tobacco plant must be destroyed by burning by the end of May each year. If the plants are pulled up immediately the last of the leaf has been picked and are left lying on the ground for a few weeks during the dry, hot weather usually experienced during March, little difficulty will be encountered in getting them burnt. Should this operation be delayed until the rains have set in in April, however, it will be very much more difficult to accomplish.

A Review.

INSECTS OF CITRUS AND OTHER SUB-TROPICAL FRUITS.

By HENRY J. QUALE.

(Pp. VII. and 583 with 377 figures. Ithaca, New York Comstock Publishing Company Inc., 1938. Price 5 dollars.)

H. J. Quale is Professor of Entomology in the University of California and Entomologist in the University of California Citrus Experimental Station. Therefore he is well qualified to deal with the problems which he has so ably treated in his recent volume.

The book primarily deals with the citrus pests of the United States of America, but Professor Quale's experience in various of the important citrus growing sections of the world enables him to include all the chief centres in his discussion.

In addition to citrus pests the author deals with the insects and mites attacking such sub-tropical fruits as the Vinifera grape, Persian walnut, almond, pecan, fig, olive, oriental persimmon, date and pomegranate. Much practical as well as purely scientific material is contained in the 583 pages and the book should prove equally valuable to orchardists, students, and entomologists.

Of the insects mentioned those of chief interest to Western Australian readers would be the Red Scale (*Aonidiella aurantii*), the Black Citrus Aphid (*Toxoptera aurantii*), the Orange Rust Mite (*Phyllocoptes oleivorus*), the Fruit Fly (*Ceratitis capitata*), the Black Scale (*Saissetia oleae*), the Brown Scale (*Coccus hesperidum*), and the Orange Piercing Moth (*Othreis materna*).

Red Scale (*Aonidiella aurantii* Maskell) is undoubtedly the most serious citrus pest found in Australia and a very comprehensive account of this insect as it occurs in various parts of the world is given.

Two extremely useful chapters on fumigation and spraying will be found at the end of the book and they are well worth attention.

A historical account of fumigation treatment is given, together with an exhaustive discussion upon fumigation injury and the responsible factors.

Professor Quale has always taken a keen interest in biological methods of control and a special chapter deals with this topic. Of interest to growers in this State is the control of Red Scale by the wasp *Aphitis chrysomphali* and the subjection of Black Scale by three parasites, *Metaphycus lounsburyi* and *Tomocera californica* and *Scutellista cyanea*.

In conclusion it must be said that Professor Quale has dealt very capably with a very difficult subject and his book is one which no citrus grower or entomologist can afford to neglect.

(C. F. H. Jenkins.)

WESTERN AUSTRALIAN EXPORT LAMBS, 1937.

J. E. NICHOLS, F. L. SHIER, AND R. P. ROBERTS.

The export of frozen lamb from Western Australia to the United Kingdom commenced in 1906 with the shipment of an experimental consignment of 422 carcasses by the R.M.S. "Brittania." The lambs, which were forwarded by the W.A. Producers' Union Ltd., were drawn from the Wagin, Beverley and Toodyay districts.

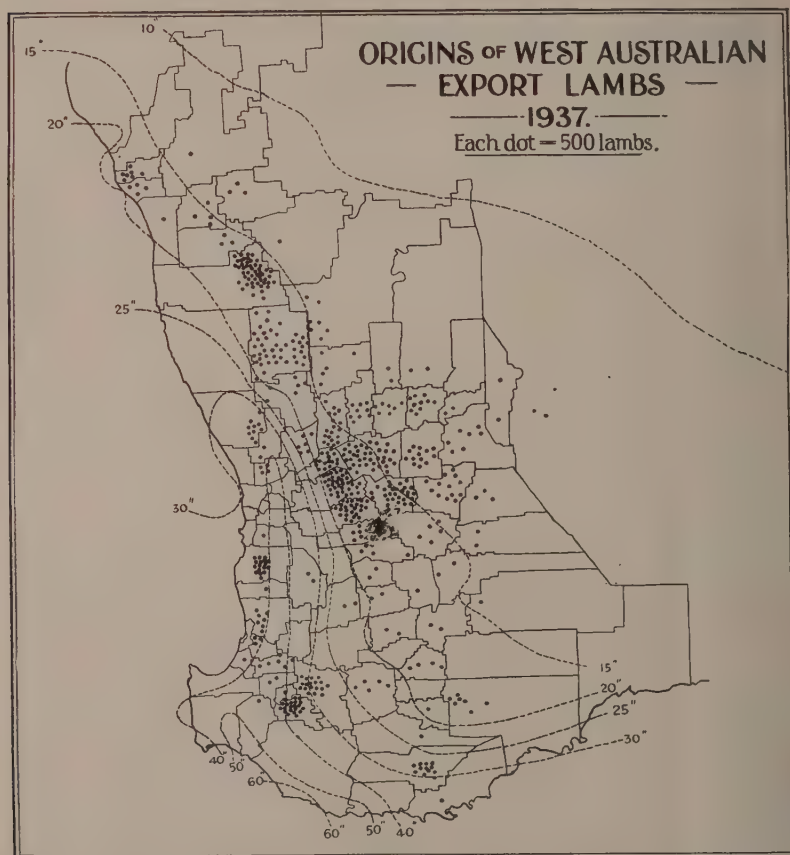


Fig. 1.

They reached London in excellent condition and realised up to 6 $\frac{3}{4}$ d. per lb. The export trade expanded rapidly in the next two or three seasons, largely under the stimulus of the relatively low prices then being received for wheat. However, between 1914 and 1929 the trade declined and it was not until 1930 that regular shipments recommenced. The progress since that date is shown by figures obtained from the Government Statistician and summarised in Table 1.

TABLE 1.

NUMBER OF LAMBS EXPORTED FROM WESTERN AUSTRALIA, 1930-1937,
TOGETHER WITH AVERAGE PRICES PER HEAD.

Year.	No. of carcases.	F.O.B. Value per carcase (excluding skin, by-products, etc.).	
		s.	d.
1930	22,826	...	...
1931	63,189	16	2
1932	10,527	13	10
1933	39,513	11	11
1934	113,454	17	5
1935	168,201	16	4
1936	143,949	17	0
1937	269,260	17	4



Fig. 2.

This rapid expansion of production since 1929 can be ascribed to the relatively attractive prices which have been maintained for lamb, as compared with those for wheat and merino wool, and to the existence in W.A. of considerable areas favourably situated for lamb raising. The extension of the subterranean clover belt is also becoming of increasing importance in the expansion of the lamb industry.

In the agricultural districts of Western Australia there is a well defined seasonal change from cool wet winter to hot dry summer, and the farming practices necessitated by those climatic conditions are also favourable to the incorporation of lamb production. The lambs are dropped in the autumn and leave the farm in the late winter and spring, so that the greatest numbers of sheep are carried during the months when there is usually plenty of green feed available.

The lambs available for export each year are influenced in both quantity and quality by seasonal conditions. The best years are those in which the pastures and fodder crops germinate early in the autumn, and do not receive any subsequent set-back by dry weather. Early rains are very valuable provided they are not immediately followed by dry hot weather which kills the young plants, giving rise to conditions even worse than when the germinating rains do not eventuate until the end of May or early June.

For the first four or five years after export had recommenced in 1930 the percentage of first-grade lambs produced each year was a reasonably good indication of the type of season which had been experienced in the lamb producing districts, but in recent years production has been extending over a much greater area, so that caution must be exercised when attempting to draw conclusions from figures which give averages for the producing districts of the whole State.

In comparing figures for percentages of grades exported account has also to be taken of the effects of supplies in other States and the demands of local consumption. For instance, the standard of lamb bought by exporters locally is likely to be affected by the extent to which their total requirements can be met from other States.

The yearly grading figures for the period 1930-37 are given in Table 2—

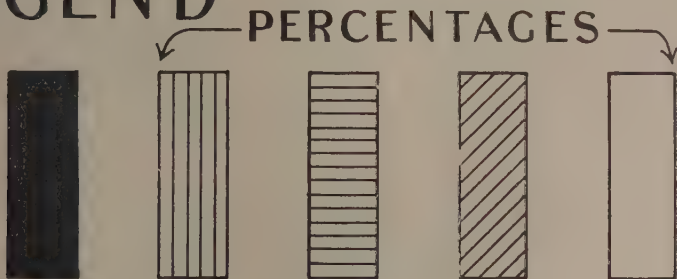
TABLE 2.

GRADING OF WEST AUSTRALIAN EXPORT LAMBS, 1930-37.

Year.			Firsts.	Seconds.	Thirds.	Rejects.
1930	...	...	33.0	36.7	20.0	10.3
1931	...	...	34.5	44.4	18.0	3.1
1932	...	...	51.7	26.3	17.6	4.4
1933	...	...	37.8	22.1	37.2	2.9
1934	...	...	51.8	24.6	21.1	2.5
1935	...	...	38.3	38.4	21.5	1.8
1936	...	...	26.9	38.9	30.9	3.3
1937	...	...	32.0	37.2	27.7	3.1

While the good seasons of 1932 and 1934 are directly expressed in this table by the high percentage of first-grade carcasses, the precise effects of varying seasonal conditions on the grading of one year's lambs as a whole cannot be suggested without further studies. So far this necessarily detailed type of investigation has been made only for one year, i.e., 1937, an account of which is given here. The authors have made no attempt to forecast the future economic position of the industry in the light of possible future demand and potential supply, but have confined themselves mainly to an analysis of the available figures of the lambs treated for export in Western Australia in 1937. It is hoped to make similar studies in subsequent years.

LEGEND



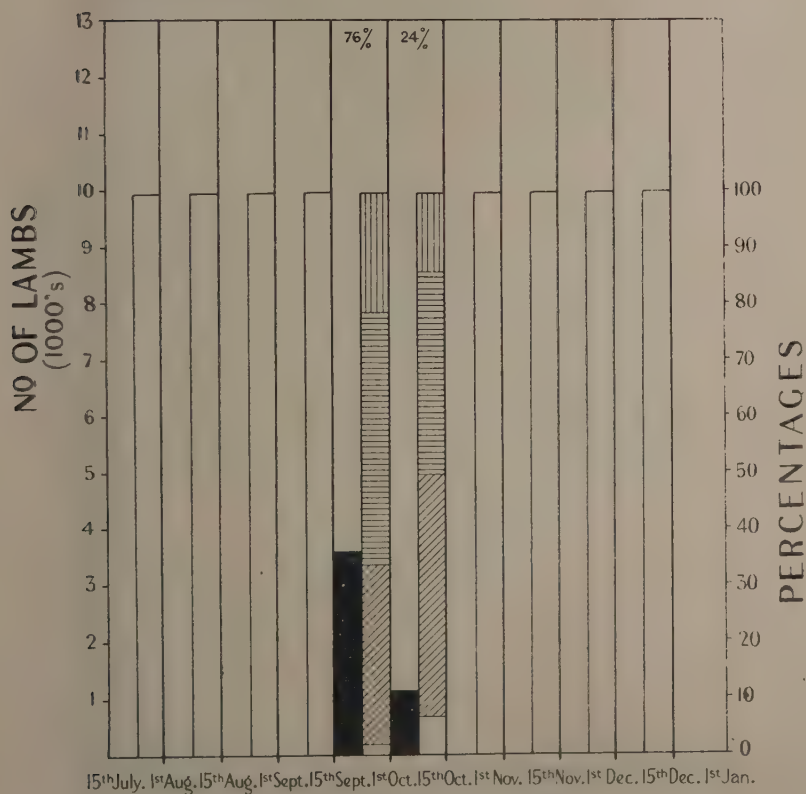
No of lambs—First
treated.

Second
grade.

Third
grade.

Rejects.

NORTHERN



PERIOD

Fig. 3.

Grading at all treatment works throughout Australia is under the control of the Commonwealth Department of Commerce and officers of that Department make periodical visits to the different works to see that a uniform standard is maintained.

The statistical information available for Western Australia is well suited to an analysis of this type, as there is no interstate movement of lambs for export; all the lambs treated for export pass either through the W.A. Meat Export Works at Robb's Jetty, Fremantle, or the Albany Freezing Works at Albany.

MIDLANDS

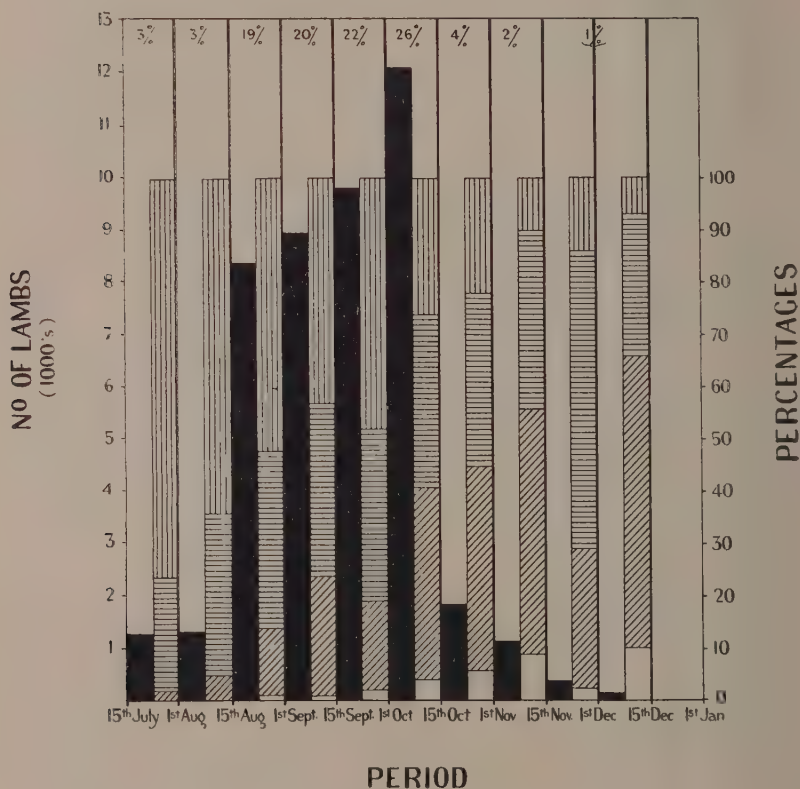


Fig. 4.

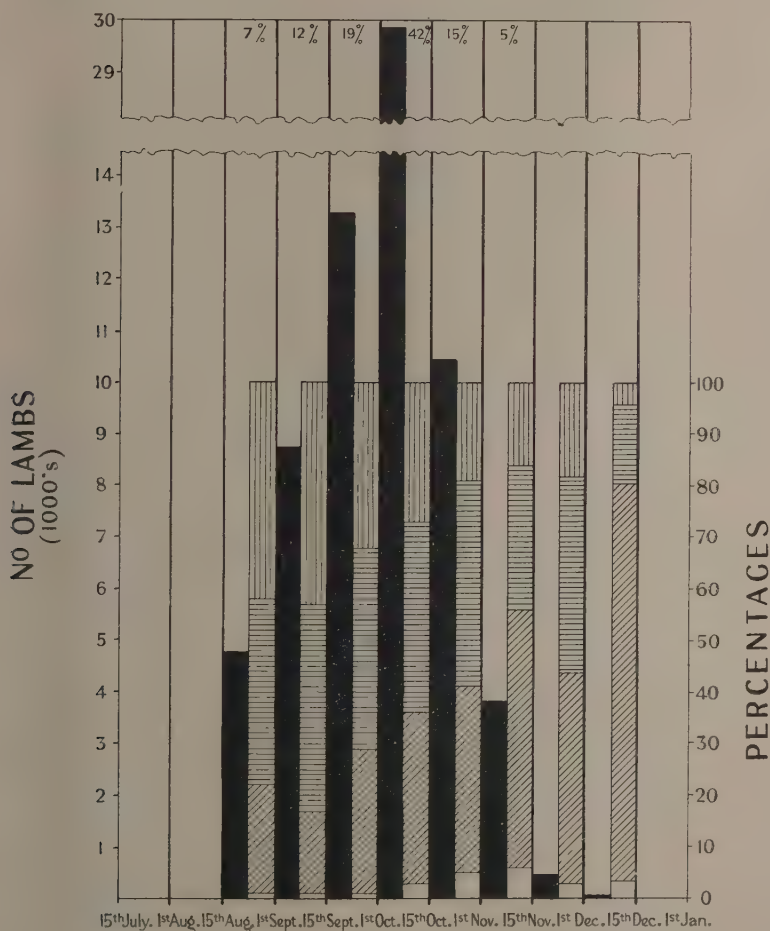
There are several ways in which the farmer may dispose of his lambs when they are ready for export. He may consign them to London agents, in which case they are forwarded to the works, where all arrangements are made for handling, shipping, insurance, etc., etc. The farmer receives the actual London returns, plus skin values and caul fat, less handling charges, freight and commission, due allowance being made for exchange.

A second method is that of selling on the farm to one of the meat exporting firms on the basis of so much per head, or on a poundage basis on the outturn at the works. Owing to the keen competition for lambs, following the entry into the

market since 1936 of some of the large meat exporting companies, this is now probably the most popular way of disposing of the lambs.

Where sufficient lambs have been available at a particular time, country auction sales have been arranged at some centres. This system has advantages for the producer, but is unsatisfactory to the buyers and agents unless a large yarding is available.

CENTRAL



PERIOD

Fig. 5.

A fourth method of disposing of the lambs is to forward them to the weekly Metropolitan markets at Midland Junction. Here they may be bought for the local trade or taken by the meat buying companies for export purposes. During

the 1937 season approximately 276,000 lambs were treated at the export works at Robb's Jetty and Albany, of which 69,000 were obtained through the Midland Junction markets.

After slaughter and dressing, and before passing to the freezers, the lambs are examined by the meat inspectors and are either rejected or passed as fit for export. The carcasses are next weighed and graded and these particulars recorded. As the main feature of this study is an analysis of grading statistics, it is important that the significance of the grades should be appreciated.

EASTERN

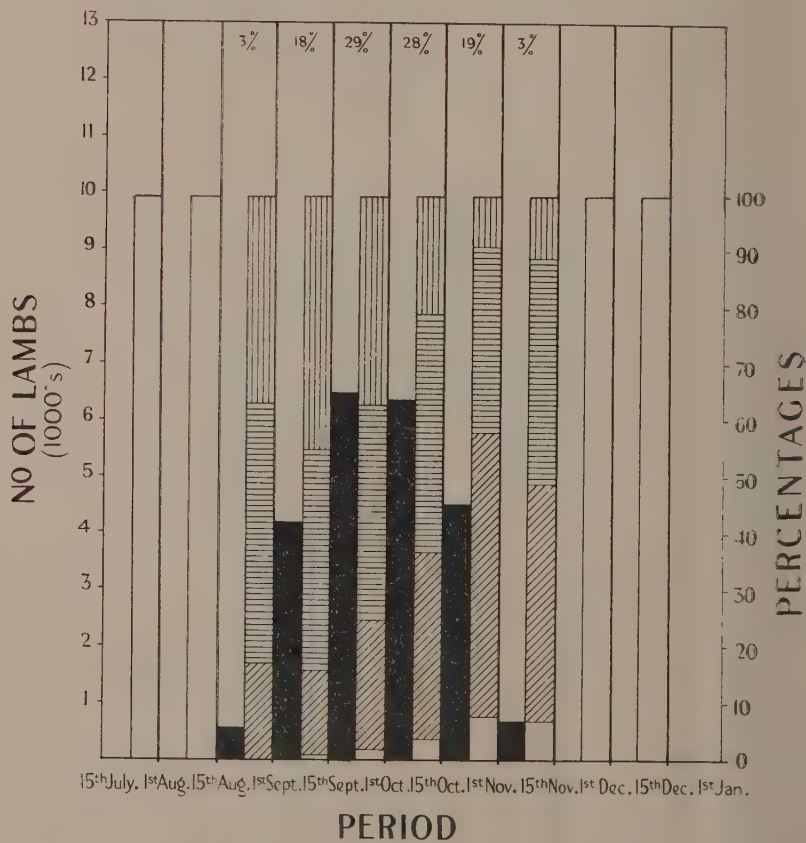


Fig. 6.

The three grades discussed in this paper are described in the Commonwealth Regulations as follows:—

“First Quality.”—Carcases shall be of reasonably good conformation, with well developed loins, legs and shoulders, good bloom and attractive appearance. The external covering of fat must extend evenly over the loins, back, shoulders and legs. Carcases showing defective covering of the loins or back not to be graded as first quality. The internal fatty covering of the loin and kidneys to be well developed, but excessive internal fat is not necessary.

Second Quality.—Carcases to be of reasonably good conformation, with well developed loins, legs and shoulders, good bloom and appearance. The external covering of fat to extend over the loins, back, shoulders and legs, but not necessarily completely covering the underlying muscle of the loins and back. Greater latitude to be allowed in the fatty covering of the shoulders and legs than in the case of first quality lambs. Internal fatty covering of the loin and kidneys to be reasonably well developed.

Third Quality.—This quality grade includes carcasses which in conformation and development of the loins, legs and shoulders, do not comply with the requirements of second-quality. The bloom and general appear-

SOUTH WEST

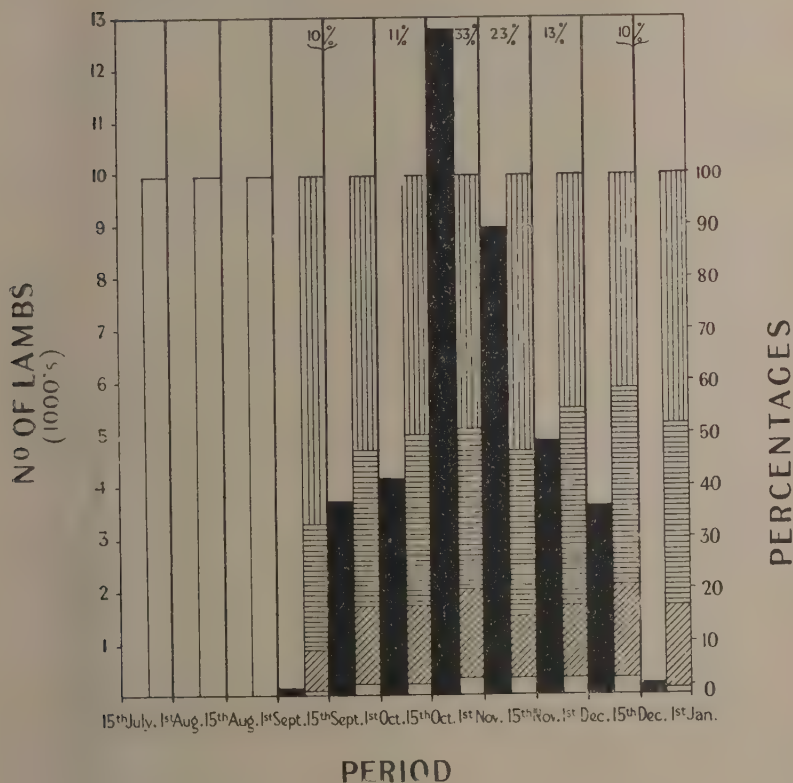


Fig. 7.

ance not so attractive and the external covering of fat on the back and loins defective. Carcases, however, which do not possess a sufficient covering of fat over the back and loins to protect the underlying muscle during the process of freezing and of storage and transport are not to be included and are to be rejected for export. Internal fatty covering of the loins and kidneys lightly developed, but must be firm in texture."

In addition, some exporters have the "down" lambs graded out separately. As well as conforming to the general standards laid down for first-grade lambs

(b) information concerning the origins of 69,000 lambs which were sold in the Midland Junction markets to the meat exporters. After passing through this central market the individual consignments lost their geographical identity and grading figures could not be obtained.

The districts of origin of the total 276,000 lambs are shown diagrammatically in Figure 1, while Figure 2, showing railways, road board districts, etc., has been included as a key.

For the purpose of this study all the lamb producing areas to the east of the 15in. rainfall line are grouped together and referred to as the Eastern districts. To the west of this line Mingenew and other road board districts northwards are referred to as the Northern districts. Three Springs, Carnamah, Moora, Dandarragan and the northern portion of Victoria Plains constitute the Midlands. The Central district includes Gingin, Chittering, Swan, Toodyay, Northam, York, Beverley, Brookton and those parts of Goomalling, Meckering and Quairading to the west of the 15in. isohyet. The South-West consists of all road board districts to the west of the 25in. rainfall line south of Perth and extending east as far as the east boundaries of the Upper Blackwood and Manjinnup districts. The Great Southern district lies between the 15in. and 25in. rainfall line south of Brookton and Quairading and north of Katanning and Kent. The Kojonup, Cranbrook, Plantagenet, Denmark, Albany, Gnowangerup, Tambellup, Broomehill, Katanning and Kent districts constitute the Lower Great Southern.

These seven zones or districts contributed to the total 275,963 lambs treated for export in the proportions set out in Table 3.

TABLE 3.

LAMBS TREATED FOR EXPORT ACCORDING TO DISTRICTS OF ORIGIN.

District.	Lambs for which complete grading information was available (207,000).		Lambs for which complete grading information was not available (68,963).		Total lambs treated (275,963).	
	Per cent.	No.	Per cent.	No.	Per cent.	No.
Northern	2	5,207	1	2	2	5,207
Midlands	22	53,218	12	19	19	53,218
Central	34	102,404	45	37	37	102,404
Eastern	11	45,327	32	16	16	45,327
South-West	19	41,024	3	15	15	41,024
Great Southern	5	14,137	6	5	5	14,137
Lower Great Southern	7	14,646	1	6	6	14,646
Totals	100	275,963	100	100	100	275,963

The percentage distribution of the 68,963 lambs which passed through the Midland markets, and for which complete grading information was not available, is shown in the second column of Table 3. It will be seen that the proportions of the lambs coming from the different districts are not precisely the same as those for which complete grading figures were available. They were distributed in such a way as to reduce the percentage contributions of the Midland and South-West lambs in the total averages and increase those of the Central and Eastern districts. This has to be remembered when drawing conclusions for the State as a whole on the basis of the 207,000 lambs for which complete information was obtained.

The contributions of the different districts to the lambs received at the works during half-monthly periods throughout the killing season are shown in Table 4. These figures refer to the 207,000 lambs mentioned previously.

TABLE 4.
CONTRIBUTIONS OF DISTRICTS TO LAMBS RECEIVED AT WORKS DURING HALF-MONTHLY PERIODS.

District.	Per cent. for—										
	16th 31st July.	1st-15th Aug.	16th 31st Aug.	1st-15th Sept.	16th 30th Sept.	1st-15th Oct.	16th 31st Oct.	1st-15th Nov.	16th 30th Nov.	1st-15th Dec.	16th 31st Dec.
Northern	...	...	...	...	9	2	...	...	...	...	...
Midlands	...	84	59	38	24	21	5	6	5	3	...
Central ...	...	3	33	37	33	51	29	19	6	2	...
Eastern ...	...	...	4	18	16	11	13	4	...	...	...
South-West	...	...	...	1	9	7	36	45	72	70	100
Great Southern	...	13	4	1	2	5	8	9	5	...	...
Lower Great Southern	...	...	...	5	7	3	9	17	12	25	...
Total (per cent.) ...	100	100	100	100	100	100	100	100	100	100	100
Total (No.) ...	1,265	1,595	14,322	23,450	40,511	58,362	35,394	19,885	6,815	5,195	206

In Table 5 the gradings of the 1937 lambs are given according to districts.

TABLE 5.

GRADING OF WESTERN AUSTRALIAN EXPORT LAMBS ACCORDING TO DISTRICT OF ORIGIN, 1937.

District.	Firsts.	Seconds.	Thirds.	Rejects.
Northern	19.5	42.5	34.5	3.5
Midlands	40.5	33.2	23.8	2.5
Central	28.7	37.7	30.7	2.9
Eastern	27.3	38.7	30.2	3.8
South-West	49.2	32.9	15.1	2.8
Great Southern	34.3	38.4	23.3	4.0
Lower Great Southern ...	54.4	34.9	8.8	1.9
State	32.0	37.2	27.7	3.1

LOWER GREAT SOUTHERN

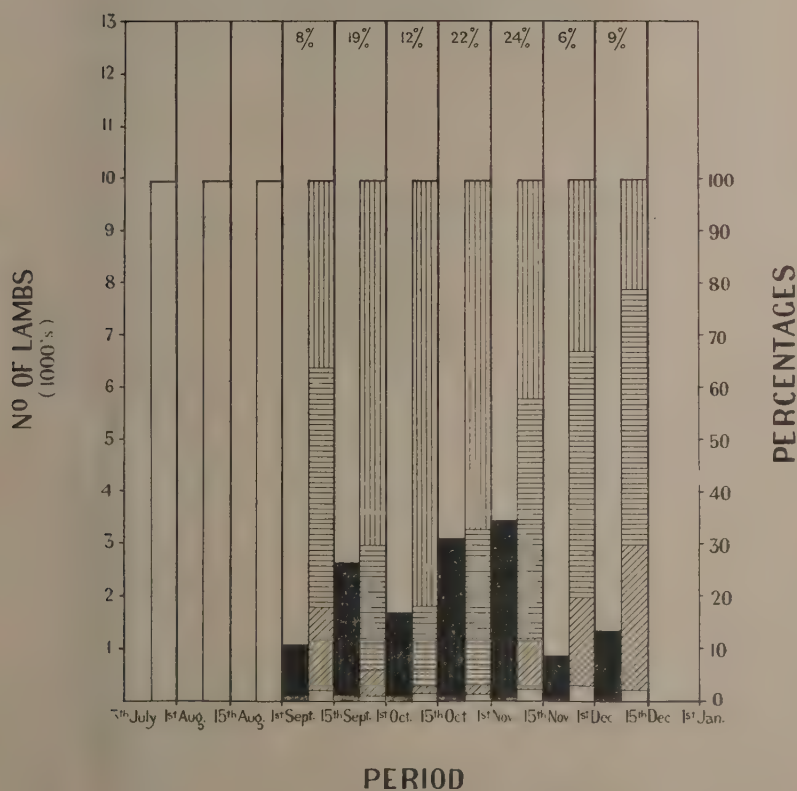


Fig. 9.

In Figures 3-9 are shown for each district—

- (1) The total numbers of lambs received for export at the freezing works during half monthly periods (in black), and
- (2) The percentage grading figures for each of these periods (hachuring).

In connection with all the figures used to make comparisons between districts, it must be borne in mind that lamb production in three of them, i.e., Great Southern, Lower Great Southern and Northern, is, as yet, relatively small, and that the numbers of lambs from these districts are too few to allow of any very definite conclusions to be drawn concerning them. All three of them are likely to expand their production rapidly in the next few years should there be no radical alteration in the economic position of the industry.

A study of the graphs for the main producing districts reveals a number of interesting points, perhaps the most noticeable of which is the rapid falling off in quality of lambs from the lower rainfall districts as the season advances. In the South-West and Lower Great Southern, on the other hand, which enjoy a heavier rainfall, the quality was fairly well maintained throughout the season. In the Midlands and Northern districts the winter rains usually commence at about the same time as in the Central, Eastern and Great Southern districts, but as winter temperatures are somewhat milder, growth of crops and pastures is rather more rapid, particularly in the early spring. In the South-West and Lower Great Southern, on the other hand, the rainy season is longer and the rains heavier than in the Midlands, but winter growth is very slow during the association of low temperatures, excess water and insufficient sunshine. It is not until the advent of warmer weather in September and October that the flush period for feed commences. The transition from winter to summer feed conditions becomes of increasingly shorter duration as one goes north or east.

It would be anticipated, therefore, that the Midlands would produce the main bulk of its lambs rather earlier, and the South-West and Lower Great Southern rather later than would the Central and Eastern districts.

The data presented show that this actually was the case in 1937. In the latter part of July and the first half of August the Midlands provided the bulk of the lambs marketed. Lambs from the Central districts began to come in in quantities in the latter part of August, but did not reach their maximum until the first half of October, the peak period of activity, in which they constituted 51 per cent. of the total receivals.

Up to the middle of October contributions from the South-West were relatively unimportant, but after that date to the finish of the season in December the South-West supplied a steadily increasing percentage of the receivals.

Seasonal effects in the various districts are also apparent in the grading figures. Where the season is short the lambs grade well in the early part, but fall away badly towards the end. In the South-West and Lower Great Southern, with their longer growing season, finishing and marketing, can be extended over a longer period.

The areas lying outside the 15in. rainfall line, which have been designated the Eastern districts, are not generally regarded as suitable for fat lamb production, and in 1937 from this extensive area only 45,000 lambs were treated for export. The season was not a favourable one in these districts, yet the quality of the lambs forwarded for export was little below that of the Central districts' lambs. The reasons for this situation cannot be directly advanced on the basis of one year's information.

Summary.

An analysis of available statistics of lambs treated for export in Western Australia during the 1937 season is presented.

The statistics concerning grading etc., were analysed on a district basis and comparative figures obtained for seven districts with respect to fluctuations in numbers of lambs coming forward and quality of carcasses throughout the export period.

The bulk of production is at present from the Central, Midlands, Eastern and South-West districts.

The season commenced towards the end of July and finished at the end of December, with a period of maximum activity from the middle of September to the end of October.

The effect of seasonal conditions in the main districts on quality and time of delivery is briefly discussed.

The authors wish to acknowledge their indebtedness to the many people and organisations who gave assistance in the preparation of this paper. Without the ready co-operation of the W.A. Meat Export Company and the Albany Freezing Works, whose officers were responsible for the compilation of the whole of the details concerning grading of individual consignments of lambs, the study could not have been undertaken. Messrs. Elder, Smith and Company; Dalgety and Company; Goldsbrough Mort and Company, and The Westralian Farmers Ltd., supplied statistical information relating to those lambs which were sold through the Midland Junction saleyards. Lands Department draftsmen compiled the block diagrams—Figs. 3 to 9. Helpful criticism and advice came from Mr. A. M. Stewart, of the Institute of Agriculture, and Mr. N. Davenport, of the Department of Agriculture. To all these people the authors extend their thanks.

THE COST OF FEEDING PURE BRED DAIRY COWS UNDER THE AUSTRALIAN OFFICIAL HERD RECORDING SCHEME.

Western Australia, 1937-8.

G. K. BARON-HAY, Superintendent of Dairying.

(J. SLATER.

This article, which is compiled annually from figures obtained in connection with the Pure Breeds Herd Recording Scheme, is published as an indication to breeders of how wide is the range of feeding costs, and in the hope that the information may assist in reducing the average cost of feeding by a judicious use of pasture, succulent conserved fodder, and, wherever possible, home-grown crops.

As the herds included are dotted over the whole area of the South-West and extend as far north as Geraldton and west to Doodlakine, naturally the climatic conditions will vary greatly, as will the costs of producing home-grown fodders. For this reason the average wholesale market price for the various concentrates has been used so that a more true comparison of the husbandry may be made.

It is not intended that these tables should figure in the nature of a competition, consequently the owners' names have been replaced by a herd letter. Any breeder, however, may obtain the identification of his herd by applying to the Department of Agriculture.

Table I. sets out the prices of the feeding stuffs used in arriving at these costs.

TABLE I.

PRICES USED IN VALUATING THE FOODSTUFFS CONSUMED DURING THE YEAR ENDED 30TH JUNE, 1938.

	£	s.	d.
Chaff (per ton)	5	0	0
Wheat, crushed (per bushel)	0	4	11
Oats	0	2	7
Bran (per bushel)	0	1	4
Pollard (per bushel)	0	1	4
Silage (per ton)	0	10	0
Meggitt's Meal (per ton)	17	7	0
Proteena (per ton)	12	0	0
Cowmeal (per ton)	15	3	0
Keymeal (per ton)	12	0	0
Halmeg (per ton)	14	11	0
Brewer's Grains (per bushel)	0	0	5
Green Lucerne (per ton)	1	0	0
Green Maize, Sudan Grass and Cereal Crops—			
Chaffed (per ton)	0	15	0
Grazed (per head per week)	0	2	6
Meadow Hay (per ton)	3	0	0
Pasture (per head per week)—			
Good, green	0	2	6
Dry	0	1	6

Table II. shows the average results over the past 15 years. The slight drop in average butter-fat production probably is due to the inclusion in the Scheme of three newly formed herds.

TABLE 2.

PURE-BRED COWS UNDER OFFICIAL TEST—AVERAGE RESULTS OVER A PERIOD OF 15 YEARS.

Year ended 30th June.	Average Milk Yield per Cow.	Average Butter- fat per Cow.	Average Cost of Feed per Cow.	Average Cost of Feed to Produce 1lb Butter.	Average Cost of Feed to Produce 1 gall. Milk.	Average Price, Butter-fat per lb.
	galls.	lbs.	£ s. d.	pence.	pence.	pence.
1924 ...	600	319.50	10 4 10	7.70	4.09	19.5
1925 ...	652	308.59	14 13 2	10.77	6.15	17.5
1926 ...	624	312.01	14 14 7	11.15	5.66	19.0
1927 ...	602	290.72	14 10 5	12.00	5.79	19.0
1928 ...	592	280.56	15 11 4	13.34	6.34	19.5
1929 ...	629	295.10	15 1 0	12.24	5.74	20.0
1930 ...	636	294.98	14 10 3	12.74	5.10	19.5
1931 ...	643	301.60	9 14 7	7.74	3.64	16.0
1932 ...	696	318.96	10 18 3	8.21	3.76	14.0
1933 ...	664	308.60	9 2 3	7.08	3.29	11.0
1934 ...	720	333.70	10 2 6	7.28	3.37	10.0
1935 ...	682	326.61	9 18 0	7.34	3.49	12.5
1936 ...	681	320.14	8 14 7	6.54	3.08	12.5
1937 ...	685	309.31	11 5 1	8.73	3.94	14.5
1938 ...	664	306.99	10 19 7	8.58	3.97	15.0

Although the Jersey herds in Table III. show the lowest cost of production, the yields of milk and butter-fat are considerably below the average shown in Table II., and figures throughout indicate that in several of these herds the cows

are underfed, the owners relying solely on inadequate pasture without supplementing with silage or concentrates for maximum production. The market for young bulls ex comparatively low-producing dams is very limited and this aspect should receive the careful consideration of breeders.

TABLE 3.

BREEDS COMPARED AS PRODUCERS OF MILK AND BUTTER-FAT.

Breed.	Average Yield of Milk per Cow during 9 months.	Average Test.	Average Yield of Butter-fat per Cow during 9 months.	Average Cost of Feed per Cow.	Average Cost of Feed to produce 1 gall. Milk.	Average Cost of Feed to produce 1lb. Butter-fat.
	lb.		lb.	£ s. d.	pence.	pence.
Guernsey (7 herds) ...	6,187	5.23	321.93	11 6 9	4.39	8.45
A.I.S. (10 herds) ...	7,492	4.03	301.73	13 1 9	4.19	10.41
Jersey (10 herds) ...	5,584	5.24	292.59	7 17 1	3.38	6.44

This is the first occasion since the commencement of these articles on which the production of herds in the "Dry" areas has exceeded that of herds in the "Wet." This appears to bear out the statement made above that unless pasture is properly managed by renovating, top dressing and rotational grazing, it must be supplemented with concentrates.

TABLE 4.

COST IN LIGHT RAINFALL AREAS COMPARED WITH THE SOUTH-WEST.

Average.	Production.		Cost of Feed for—	
	Milk.	Butter-fat.	1 gall. Milk.	1lb. Butter-fat.
	lb.	lb.	pence.	pence.
Dry Areas (13 herds) ...	7,260	313.45	4.43	10.27
Wet Areas (14 herds) ...	5,834	293.13	3.45	6.86

Last year Mr. C. J. Cunningham's herd occupied second position in the table showing herds in order of merit as profitable butter-fat producers, and this year, although his cost of feeding has increased slightly, his herd shows as the most profitable of the 27 under review. This consistency indicates Mr. Cunningham's excellent judgment, both in breeding and feeding, as it will be noted that although his costs are lower than the average, production has not suffered. The owner of the herd at the other end of the table, owing to the situation of his holding, is in the unfortunate position of having to purchase no less than 80 per cent. of his feed and grazing is confined to poor natural grasses through a few months only of the year.

In computing the available skim milk, it is assumed that the calf consumes 60 gallons of whole milk, 10 per cent. of the milk goes with the cream, and a further 120 gallons of skim milk is fed to the calf.

TABLE 5.
HERDS IN ORDER OF MERIT AS PROFITABLE BUTTER-FAT PRODUCERS.

Place.	Herd.	District (W = Wet, D = Dry).	Breed.	Average Butter-fat per Cow for 9 months.	Available Skim Milk per Cow.	Value of Butter-fat at 1s. 3d. lb.	Value of Skim Milk at 1d. per gall.	Gross Return from Butter- fat and Skim Milk.	Cost of Feed per Cow for 9 months.	Profit per Cow.	Cost of Feed to produce 1lb. Butter- fat.
				lb.	lb.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	pence.
1	W	W	Jersey	363.64	3,838	22 14 7	1 12 0	24 6 7	8 7 2	15 19 5	5.52
2	S	W	do.	329.06	4,123	20 11 3	1 14 4	22 5 7	6 10 3	15 15 4	4.75
3	E	W	do.	296.21	3,407	18 10 3	1 8 5	19 18 8	4 10 0	15 8 8	3.64
4	M	D	Guernsey	435.41	5,361	27 4 4	2 4 9	29 9 1	14 10 2	14 18 11	8.00
5	AC	W	A.I.S.	333.09	5,887	20 16 3	2 9 1	23 5 4	8 14 2	14 11 2	6.27
6	Z	D	do.	374.60	6,550	23 8 3	2 14 7	26 2 10	12 9 10	13 13 0	8.74
7	U	W	Guernsey	303.35	3,575	18 19 2	1 9 10	20 9 0	7 5 2	13 3 10	5.74
8	D	W	do.	331.06	4,959	20 13 9	2 1 4	22 15 1	9 15 4	12 19 9	7.08
9	I	D	Jersey	339.61	3,925	21 4 5	1 12 10	22 7	10 0 3	12 17 0	7.08
10	B	W	do.	245.88	2,726	15 7 4	1 2 9	16 10 1	5 0 5	11 9 8	4.90
11	K	W	do.	277.57	3,206	17 6 11	1 6 11	18 13 10	7 10 0	11 3 10	9.68
12	L	D	do.	418.86	4,568	26 3 7	1 18 1	28 1 8	17 3 10	10 17 10	9.85
13	G	D	A.I.S.	309.49	5,054	19 6 10	2 2 1	21 8 11	11 6 3	10 2 8	8.77
14	AB	D	do.	324.87	5,385	20 6 1	2 4 11	22 11 0	12 16 0	9 15 0	9.46
15	F	D	do.	314.77	4,917	19 13 5	2 1 1	21 14 5	11 19 6	9 14 11	9.13
16	H	W	Jersey	315.02	3,465	19 13 9	1 9 0	21 2 9	11 12 11	9 9 10	8.87
17	Y	W	do.	230.68	2,060	14 8 4	0 17 2	15 5 6	6 8 8	8 16 10	6.69
18	AD	D	A.I.S.	312.19	5,360	19 10 3	2 4 8	21 14 11	13 8 11	8 6 0	10.34
19	R	W	Guernsey	314.50	3,735	19 13 2	1 11 2	21 4 4	12 18 10	8 5 6	9.88
20	AA	D	A.I.S.	291.38	4,579	18 4 2	1 18 2	20 2 4	12 1 8	8 0 8	9.95
21	AG	W	Guernsey	292.38	3,911	18 5 5	1 12 7	19 18 0	11 17 11	8 0 1	9.76
22	AF	W	Jersey	249.16	2,720	15 11 3	1 2 8	16 13 11	8 16 3	7 17 8	8.49
23	N	D	Guernsey	306.31	3,509	19 2 11	1 9 3	20 12 2	13 9 1	7 3 1	10.54
24	X	D	A.I.S.	285.69	4,722	17 17 1	1 19 4	19 16 5	14 13 3	5 3 2	12.31
25	Q	D	do.	280.28	5,094	17 10 4	2 2 5	19 12 9	15 14 4	3 18 5	13.45
26	AE	W	Guernsey	264.36	2,781	16 10 5	1 3 2	17 13 7	16 1 5	1 12 2	14.59
27	V	D	A.I.S.	276.71	4,374	17 5 11	1 16 5	19 2 4	17 16 5	1 5 11	15.45
			Average	306.99	4,239	19 3 9	1 15 4	20 19 1	10 19 7	9 19 6	8.59

Available Skim Milk = [Total Milk—60 gallons—10%]—120 gallons.

The last table, showing herds in order of merit as profitable milk producers, is headed by Messrs. Bayley Bros.' A.I.S. herd with Mr. W. G. Burges' A.I.S. herd second. Last year these places were reversed.

TABLE 6.

HERDS IN ORDER OF MERIT AS PROFITABLE MILK PRODUCERS.

Place.	Herd.	Breed.	Average Milk per Cow for 9 months.	Value of Whole Milk at 1s. gallon.	Cost of Feed per Cow for 9 months.	Profit per Cow.	Cost of Feed to produce 1 gallon Milk.
			lb.	£ s. d.	£ s. d.	£ s. d.	pence.
1	AC	A.I.S.	8,474	42 7 0	8 14 2	33 12 10	2·47
2	Z	do.	9,100	45 10 0	12 9 10	33 0 2	3·29
3	D	Guernsey	7,443	37 4 0	9 15 4	27 8 8	3·15
4	AB	A.I.S.	7,917	39 12 0	12 16 0	26 16 0	3·88
5	G	do.	7,549	37 15 0	11 6 3	26 8 9	3·59
6	S	Jersey	6,514	32 11 0	6 10 3	26 0 9	2·40
7	AD	A.I.S.	7,889	39 9 0	13 8 11	26 0 1	4·09
8	W	Jersey	6,820	34 2 0	8 7 2	25 14 10	2·94
9	F	A.I.S.	7,397	37 0 0	11 19 6	25 0 6	3·88
10	M	Guernsey	7,890	39 9 0	14 10 2	24 18 10	4·41
11	E	Jersey	5,719	28 12 0	4 10 0	24 2 0	1·89
12	AA	A.I.S.	7,021	35 2 0	12 1 8	23 0 4	4·12
13	U	Guernsey	5,906	29 11 0	7 5 2	22 5 10	2·95
14	Q	A.I.S.	7,593	37 19 0	15 14 4	22 4 8	4·97
15	I	Jersey	6,295	31 9 6	10 0 3	21 9 3	3·81
16	X	A.I.S.	7,180	35 18 0	14 13 3	21 4 9	4·90
17	K	do.	5,496	27 10 0	7 10 0	20 0 0	3·27
18	B	Jersey	4,962	24 16 0	5 0 5	19 15 7	2·43
19	AG	Guernsey	6,279	31 8 0	11 17 11	19 10 1	4·55
20	L	Jersey	7,009	35 1 0	17 3 10	17 17 2	5·89
21	R	Guernsey	6,083	30 8 0	12 18 10	17 9 2	5·11
22	H	Jersey	5,783	28 18 0	11 12 11	17 5 1	4·83
23	V	A.I.S.	6,793	33 19 0	17 16 5	16 2 7	6·30
24	AF	Jersey	4,955	24 15 6	8 16 3	15 19 3	4·27
25	N	Guernsey	5,832	29 3 0	13 9 1	15 13 11	5·54
26	Y	Jersey	4,222	21 2 0	6 8 8	14 13 4	3·63
27	AE	Guernsey	5,023	25 2 0	16 1 5	9 0 7	7·68
		Average	6,643	33 4 0	10 19 7	22 4 5	3·97

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